Kubernetes in Action

Foundations and Practice Labs

Agenda

- Introduction Round
- Intro to Kubernetes
- Kubernetes Cluster and Management
- Basic Kubernetes Objects
- Security
- Storage
- Networking
- Other Tools and Principles

Resources

- GitHub Repository
- Google Chat Space
- Feedback Form

1. Intro to Kubernetes

Containers - benefits, differences with Docker and VMs;
Container orchestration – why we need it?
Kubernetes history, FAQs, and implementations.

Containers

- Lightweight packages of application code
- Contain:
  - Dependencies
  - Language runtime(s)
  - Libraries

Benefits of Containers

- Separation of Responsibility
- Workload Portability
- Application Isolation

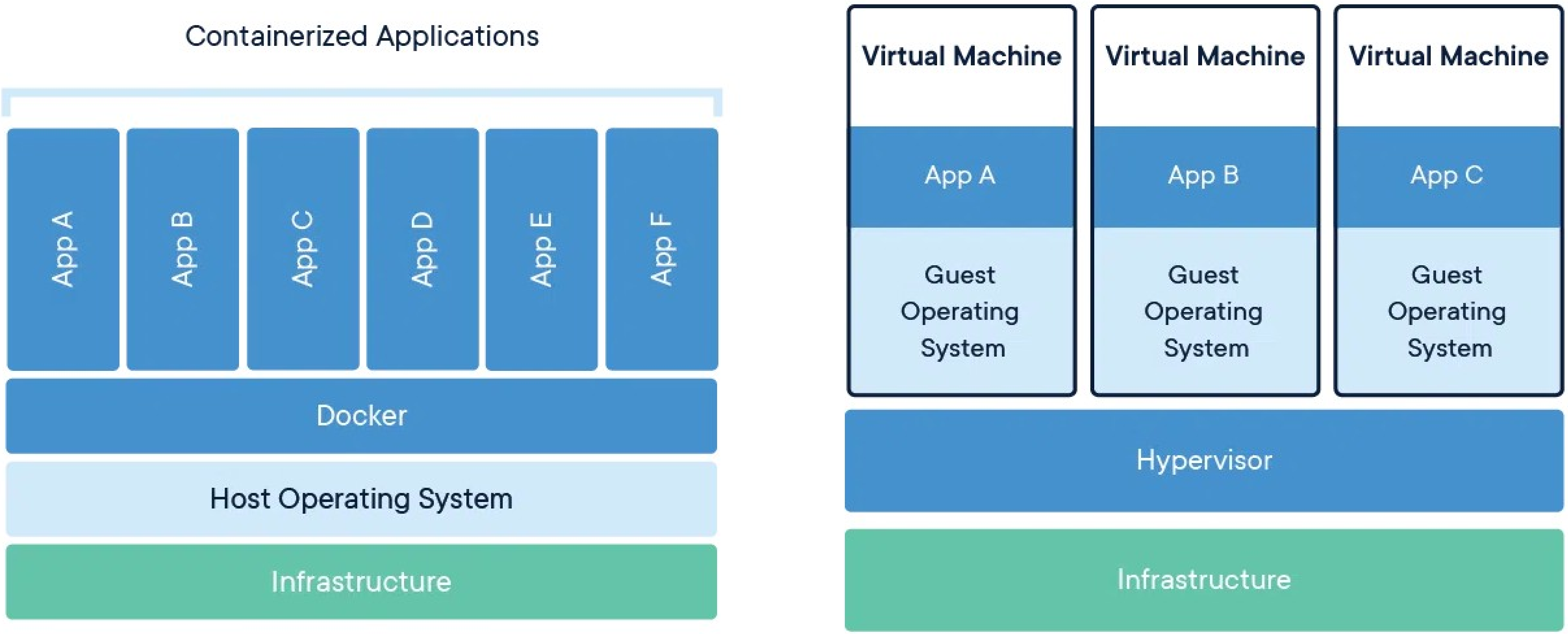
Containers and Docker

- Used synonymously, but not the same!
- Docker == container (runtime) technology
- Other technologies
  - Docker Enterprise (Docker + features + enterprise support)
  - containerd (industry standard container runtime)
  - CRI-O (lightweight and open-source)
  - LXC/LXD, BSD Jails… (container technologies for OS containers)

Containers vs VMs

- Containers more lightweight than Vms
- Containers virtualize at the OS level
- VMs virtualize at the hardware level
- Containers share the OS kernel and use a fraction of the memory VMs require

Containers vs VMs



Why Container Orchestration?

- Managing complexity of running containers at scale
- Automated Management
- Efficiency
- Scalability
- Consistency and Efficiency
- Security
- Declarative Configuration

Kuberentes - Brief History

- Why K8s?
- 2003-2004 – Google introduced Borg
- 2013 – Google releases Omega
- Mid 2014 – Google releases Kubernetes (open source version of Borg)
- July 21, 2015 – Kubernetes v1.0 is released

FAQs about K8s

- What is Kubernetes?
- What does Kubernetes do?
- What does a Kubernetes deployment look like?
- How is the Kubernetes-based container service managed?

The role of CNCF

- Cloud Native Computing Foundation
- Significant role in development and growth of K8s
  - Governance
  - Fostering community interaction
  - Driving technical vision
  - Foreseeing future growth and expansion of K8s

CNCF Landscape

Link to Map

K8s implementations

- Single node implementations (used for test, dev, IoT)
  - minikube, kind, k3s, k3d, microk8s
- Manual cluster installation
  - kubeadm
  - Kubernetes the Hard Way

K8s implementations

- Automated installations
  - Rancher Kubernetes Engine (RKE), Kubespray, Kubernetes Operations (kops), spinnaker.io, EKS Anywhere...
- Managed installations
  - Google Kubernetes Engine (GKE), Azure Kubernetes Service (AKS), AWS Elastic Kubernetes Service (EKS)...

2. K8s Cluster and Management

Architecture, components, interacting with the cluster

K8s Architecture

- Control Plane
  - Global decisions about the cluster
  - Detect and respond to cluster events
  - Consists of various components
- Worker Node
  - Where actual work runs
  - Running pods
  - Provide K8s runtime environment
  - Consists of various components

Control Plane Components

- Can run on any node of the cluster
- API Server
- etcd
- Scheduler
- Controller Manager
- Cloud Controller Manager

API Server

- Exposes the K8s API
- Front end of the K8s Control Plane
- Main implementation kube-apiserver
  - Able to scale horizontally
- Validates and configures data for the API objects
- Services REST operations
- All other components interact through API Server

etcd

- Consistent and highly available key value store
- All cluster data located here
- Database for the cluster
- Needs to have a backup plan
- Interaction through etcdctl

Scheduler

- Responsible for selecting a node for all pods
  - Which pod goes to which node
- Factors taken into account
  - Individual or collective resource requirements
  - Hardware/software/policy constraints
  - Affinity and anti-affinity specs
  - Data locality
  - Inter-workload interference
  - Deadlines

Controller Manager

- Runs *controller processes*
- Logically each controller == single process
- Compiled into a single binary
- Many different types of controllers
  - Node controller
  - Job controller
  - EndpointSlice controller
  - ServiceAccount controller

Cloud Controller Manager

- Embeds cloud-specific control logic
- Links cluster into cloud provider’s API
- Only present if running on Cloud or using managed cluster
- Some of them include:
  - Node controller
  - Route controller
  - Service controller

Node Components

- Run on every node of the cluster
- kubelet
- kube-proxy
- Container runtime

kubelet

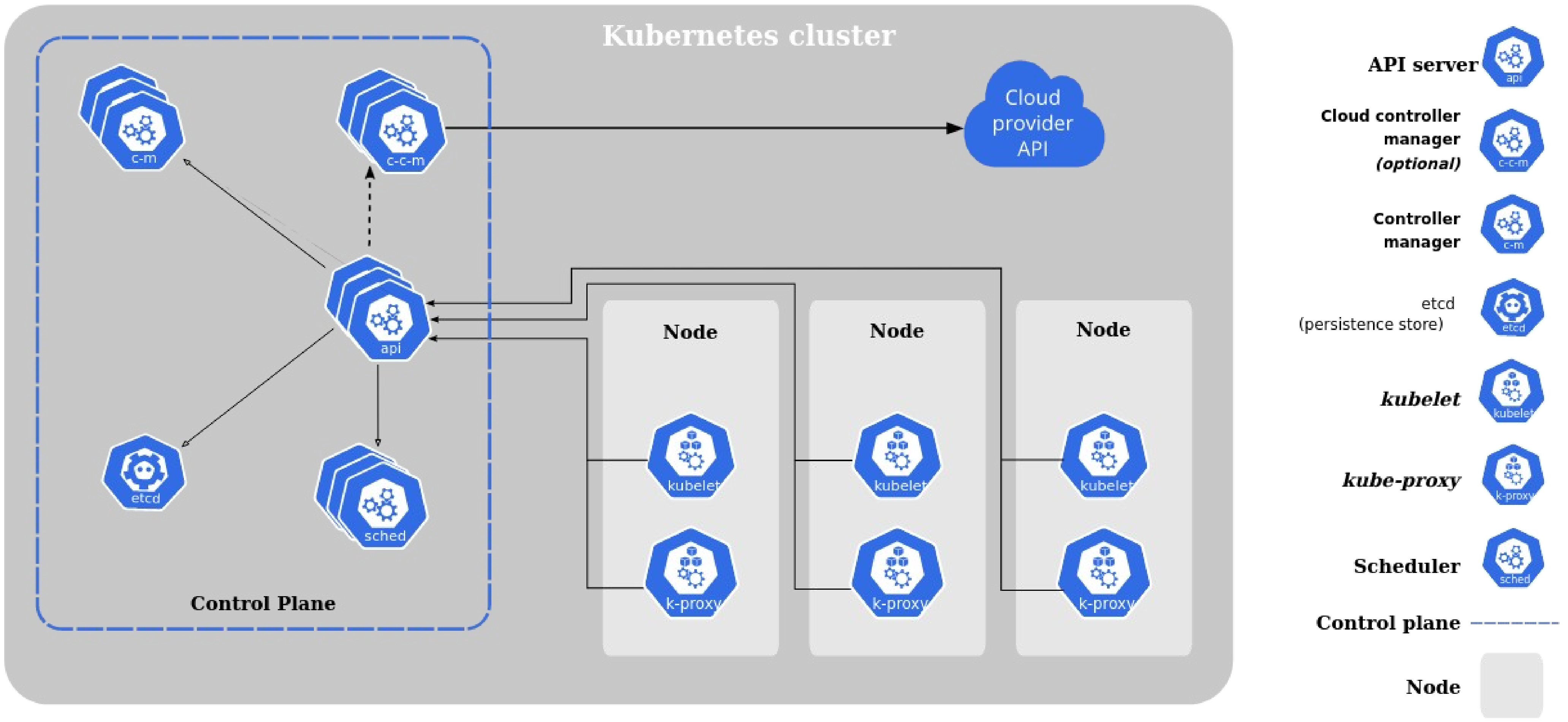
- Agent running on each node in the cluster
- Makes sure containers are running in a Pod
  - All pods are running according to their specification
- Communicates with the API server
- Doesn’t manage containers outside of the cluster

kube-proxy

- Runs on each node of the cluster
- Implements part of the K8s Service concept
- Maintains network rules on nodes
- Uses packet filtering layer if present on the OS
- Otherwise – forwards the traffic itself

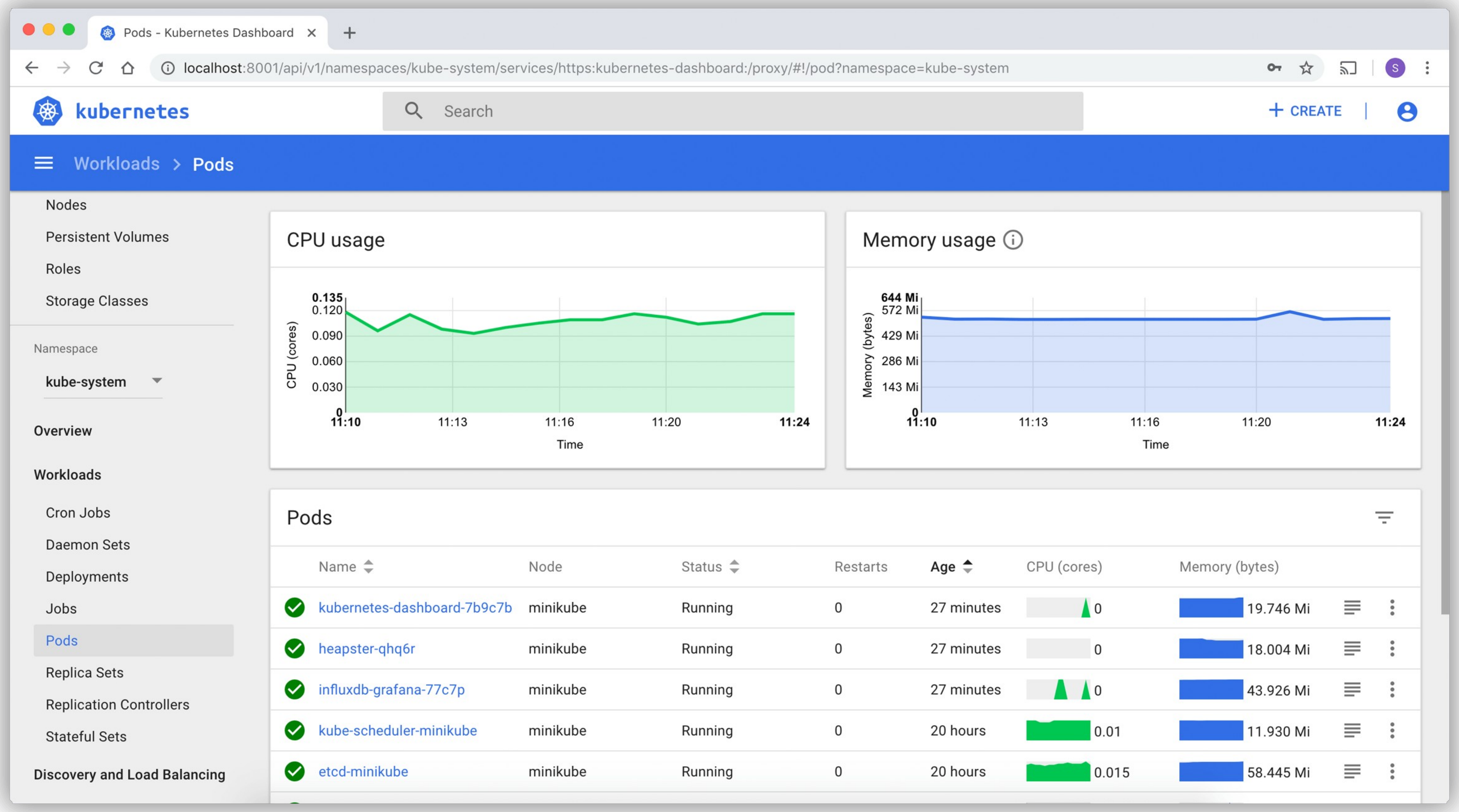
Container runtime

- Fundamental component
- Manages:
  - Execution
  - Life cycle of containers in K8s environment
- Runtime needs to support Kubernetes Container Runtime Interface
  - containerd
  - CRI-O


Kubernetes cluster
c-m
c-c-m
Cloud provider API
api
etcd
sched
Control Plane
Node
kubelet
k-proxy
Node
kubelet
k-proxy
Node
kubelet
k-proxy
API server
Cloud controller manager (optional)
Controller manager
etcd (persistence store)
kubelet
kube-proxy
Scheduler
Control plane
Node

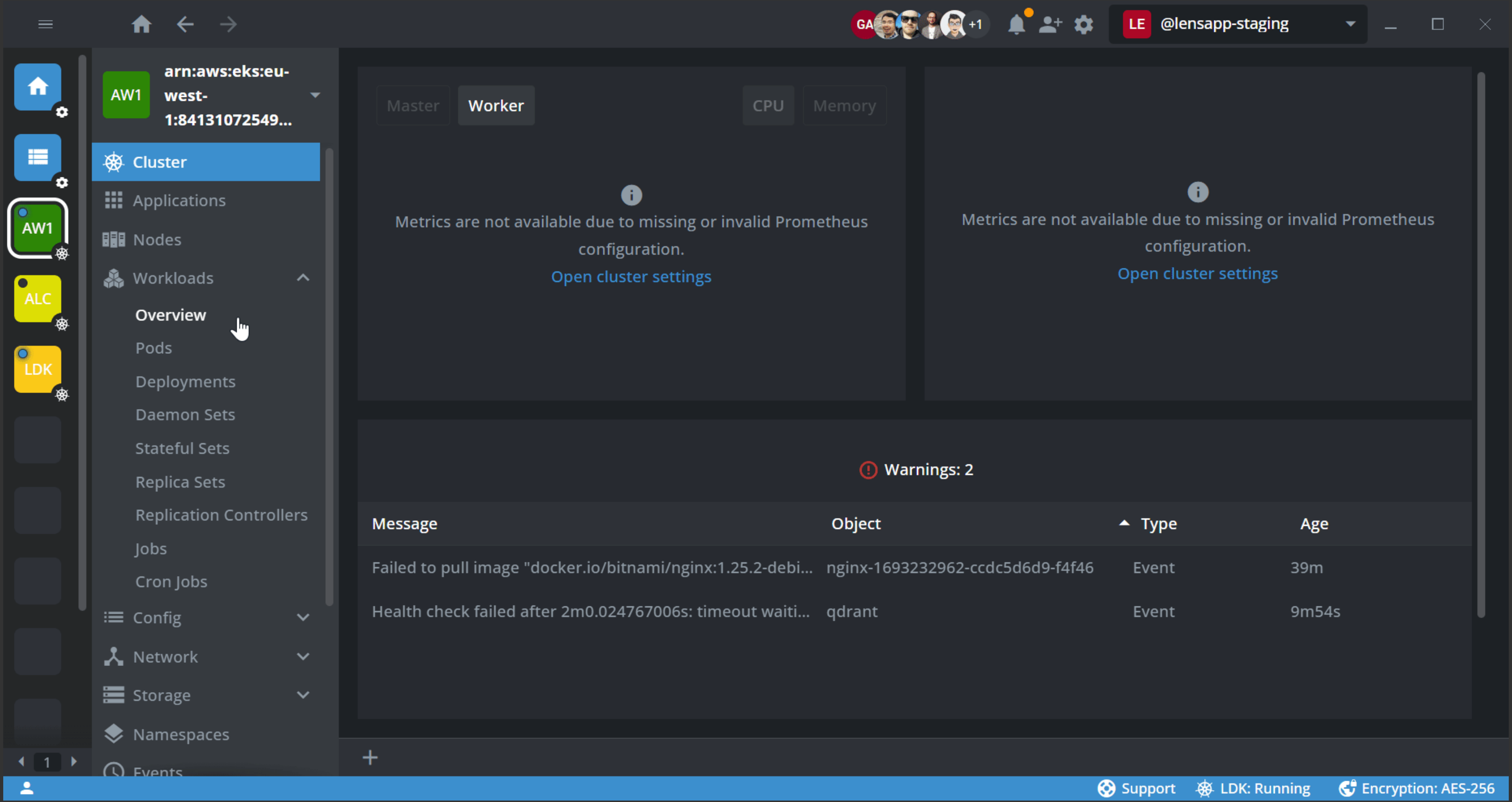
K8s Addons

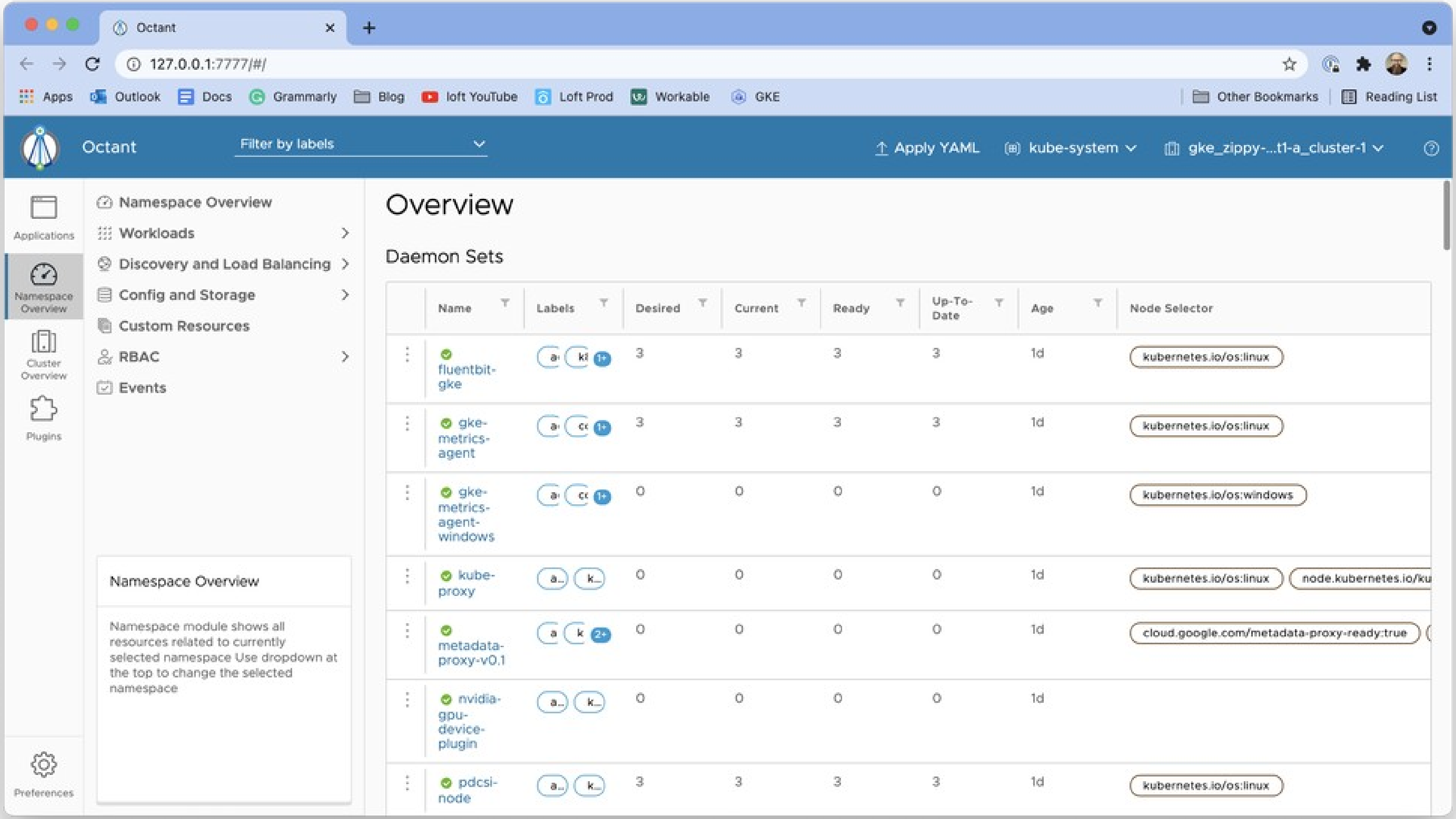
- Use K8s resources to implement cluster features
- DNS – strictly required addon (core-dns)
- Web UI (Dashboard)
- Container Resource Monitoring
- Cluster-level Logging
- Network Plugins


Pods - Kubernetes Dashboard
localhost:8001/api/v1/namespaces/kube-system/services/https:kubernetes-dashboard:/proxy/#!/pod?namespace=kube-system
kubernetes
Search
+ CREATE
Workloads > Pods
Nodes
Persistent Volumes
Roles
Storage Classes
Namespace
kube-system
Overview
Workloads
Cron Jobs
Daemon Sets
Deployments
Jobs
Pods
Replica Sets
Replication Controllers
Stateful Sets
Discovery and Load Balancing
CPU usage
CPU (cores)
0.135
0.120
0.090
0.060
0.030
0
11:10
11:13
11:16
11:20
11:24
Time
Memory usage
Memory (bytes)
644 Mi
572 Mi
429 Mi
286 Mi
143 Mi
0
11:10
11:13
11:16
11:20
11:24
Time
Pods
Name
Node
Status
Restarts
Age
CPU (cores)
Memory (bytes)
kubernetes-dashboard-7b9c7b minikube Running 0 27 minutes 0 19.746 Mi
heapster-qhq6r minikube Running 0 27 minutes 0 18.004 Mi
influxdb-grafana-77c7p minikube Running 0 27 minutes 0 43.926 Mi
kube-scheduler-minikube minikube Running 0 20 hours 0.01 11.930 Mi
etcd-minikube minikube Running 0 20 hours 0.015 58.445 Mi

Ways to interact with cluster

- Official – kubectl
- Other (third-party)
  - k9s
  - Lens Desktop
  - Octant
  - VS Code Kubernetes plugin


@lensapp-staging
arn:aws:eks:eu-west-1:84131072549...
Cluster
Applications
Nodes
Workloads
Overview
Pods
Deployments
Daemon Sets
Stateful Sets
Replica Sets
Replication Controllers
Jobs
Cron Jobs
Config
Network
Storage
Namespaces
Events
Master
Worker
CPU
Memory
Metrics are not available due to missing or invalid Prometheus configuration.
Open cluster settings
Metrics are not available due to missing or invalid Prometheus configuration.
Open cluster settings
Warnings: 2
Message
Object
Type
Age
Failed to pull image "docker.io/bitnami/nginx:1.25.2-debi...
nginx-1693232962-ccdc5d6d9-f4f46
Event
39m
Health check failed after 2m0.024767006s: timeout waiti...
qdrant
Event
9m54s
Support
LDK: Running
Encryption: AES-256


Octant
127.0.0.1:7777/#/
Apps
Outlook
Docs
Grammarly
Blog
loft YouTube
Loft Prod
Workable
GKE
Other Bookmarks
Reading List
Octant
Filter by labels
Apply YAML
kube-system
gke_zippy-...t1-a_cluster-1
Applications
Namespace Overview
Cluster Overview
Plugins
Preferences
Namespace Overview
Workloads
Discovery and Load Balancing
Config and Storage
Custom Resources
RBAC
Events
Namespace Overview
Namespace module shows all resources related to currently selected namespace Use dropdown at the top to change the selected namespace
Overview
Daemon Sets
Name
Labels
Desired
Current
Ready
Up-To-Date
Age
Node Selector
fluentbit-gke
gke-metrics-agent
gke-metrics-agent-windows
kube-proxy
metadata-proxy-v0.1
nvidia-gpu-device-plugin
pdcsi-node
kubernetes.io/os:linux
kubernetes.io/os:windows
node.kubernetes.io/ku
cloud.google.com/metadata-proxy-ready:true
1d

k9s in action!

LAB 2.1 - kubectl

- Installation
- Command structure
- Connecting to the cluster

3. Basic Kubernetes Objects

Namespaces, Pods, Deployments, ConfigMaps, Secrets, Deamonsets, Jobs, and CronJobs

What are objects?

- Persistent entities in K8s system
- Present record of intent
  - Once created, K8s system will constantly work to ensure those object exists
- Interact with Kubernetes API, usually via kubectl
- Imperative

```
> kubectl run --image=nginx nginx
```

- Declarative

```
> kubectl apply -f nginx.yaml
```

Describing a K8s object

- API Server requires JSON information
- Manifests usually provided in YAML
- kubectl does the conversion to JSON
- Required fields
  - apiVersion
  - kind
  - metadata (name, UID, and optional namespace)
  - spec (different for every Kubernetes object)

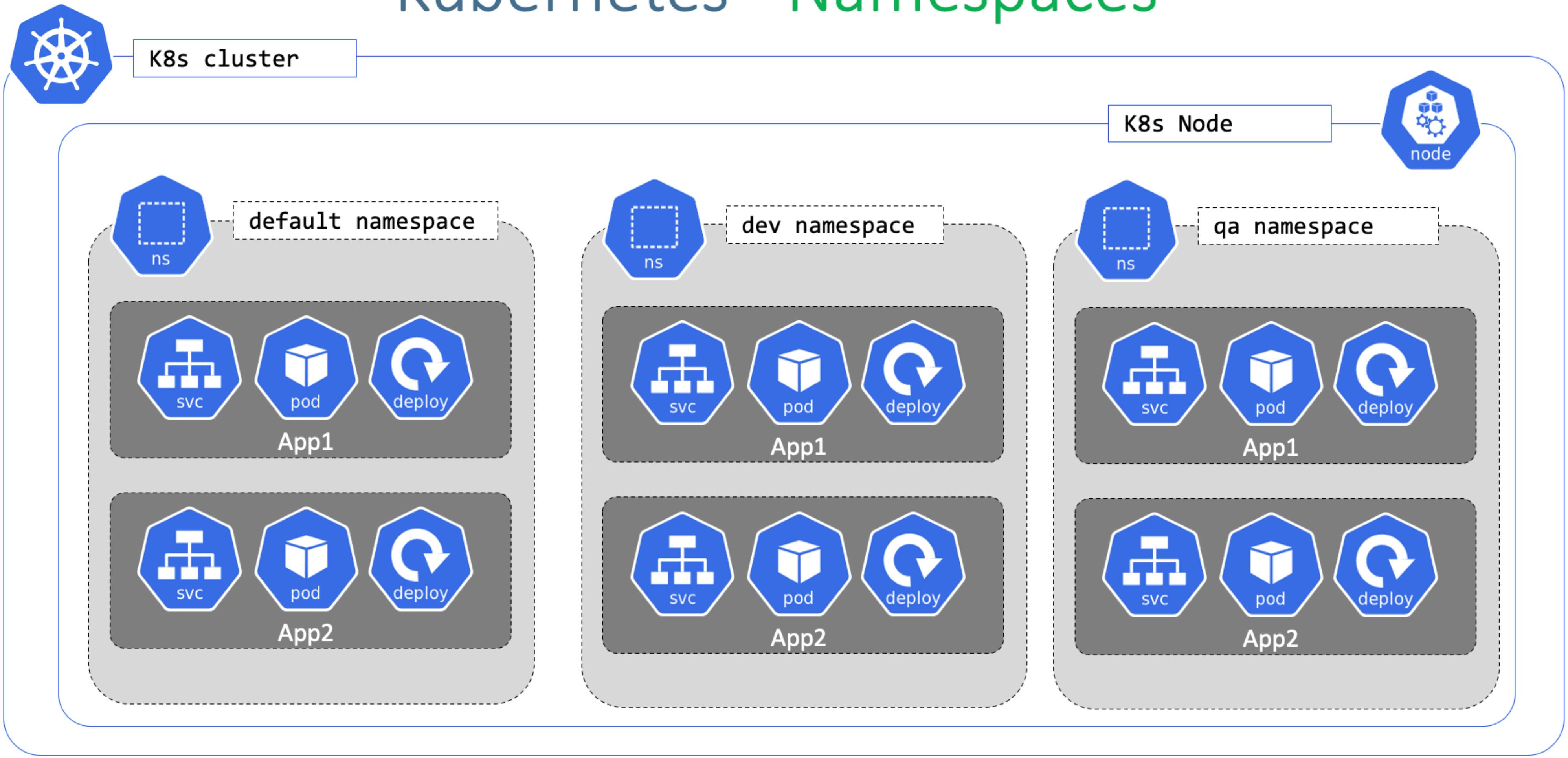
Example of a manifest

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: nginx
spec:
  containers:
  - name: nginx
    image: nginx:1.14.2
    ports:
    - containerPort: 80
```

Namespace

- Mechanism for isolating groups of resources within a single cluster
- Names of same resources needs to be unique within a namespace
- Names of namespaces needs to be unique

Kubernetes - Namespaces



Lab 3.1 – namespace

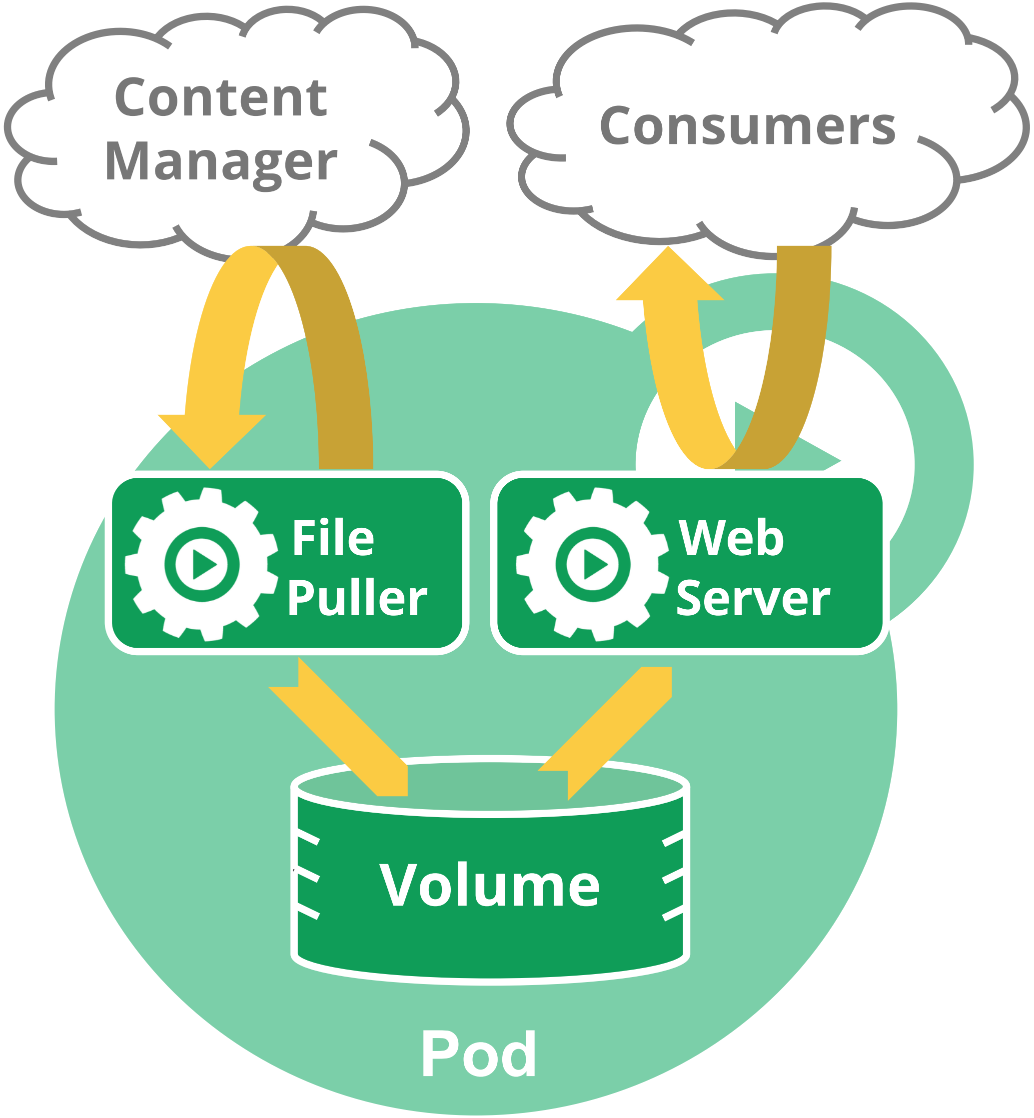
- List all namespaces
- Create a namespace imperatively
- Connect to the created namespace
- Create a namespace manifest
- Create a namespace from manifest

Pods

- Smallest deployable units of computing
- A group of one or more containers
- They share
  - Storage
  - Network resources
- Can contain one or more tightly coupled containers
- Designed as ephemeral, disposable entities

Pods

- Usually created through workload resources (Deployments or Jobs)
- Two main ways of usage
  - Pods running a single container (one-container-per-Pod)
  - Pods running multiple close connected containers (e.g. one container serves data to the public, the other refreshes or updates that data)
- **One Pod == One instance of an application**


Content Manager
Consumers
File Puller
Web Server
Volume
Pod

Lab 3.2 – Pods

- List all pods in all namespaces
- Create a Pod imperatively
- Check Pod status
- Create a Pod manifest
- Create a Pod from manifest
- Enter a Pod
- Delete a Pod

Pod Scheduling

- Scheduling == assigning a Pod to a Node
- Usually left for kube-scheduler to decide
- Couple of use-cases for declarative scheduling
  - Certain Pods require SSD disks
  - Collocate certain Pods to the same Availability Zone

Ways to schedule Pods

- nodeSelector (simplest, using Node labels)
- Affinity and anti-affinity (allow more control over the logic of scheduling)
  - Node and inter-pod affinity and anti-affinity
- nodeName (more direct, overrules the previous 2)
- Pod topology spread constraints
  - Control how Pods are spread across cluster among failure-domains such as regions, zones, nodes, or among any other topology)

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: with-node-affinity
spec:
  affinity:
    nodeAffinity:
      requiredDuringSchedulingIgnoredDuringExecution:
        nodeSelectorTerms:
        - matchExpressions:
          - key: topology.kubernetes.io/zone
            operator: In
            values:
            - antarctica-east1
            - antarctica-west1
      preferredDuringSchedulingIgnoredDuringExecution:
      - weight: 1
        preference:
          matchExpressions:
          - key: another-node-label-key
            operator: In
            values:
            - another-node-label-value
  containers:
  - name: with-node-affinity
    image: registry.k8s.io/pause:2.0
```

Lab 3.3 – Pods scheduling with nodeSelector

- Add a label to a node
- Create a manifest for a Pod with a nodeSelector field
- Apply the created manifest
- See where the pod is running
- Delete created Pods and label

Taints and Tolerations

- Taints are the opposite of NodeAffinity
  - Allow the Nodes to reject certain Pods
- Tolerations – allow the scheduler to schedule Pods to nodes with matching Taints
- Work hand in hand to ensure Pods are properly scheduled
- If node is marked with a taint – only a Pod with toleration can run there
- Use cases:
  - Dedicated Nodes
  - Nodes with Special Hardware

```
# Tainting a node
kubectl taint nodes node1 example-key=example-value:NoSchedule


---
apiVersion: v1
kind: Pod
metadata:
  name: nginx
  labels:
    env: test
spec:
  containers:
  - name: nginx
    image: nginx
    imagePullPolicy: IfNotPresent
  tolerations:
  - key: "example-key"
    operator: "Exists"
    effect: "NoSchedule"
```

Deployments

- Workload objects
- Declarative way of managing Pods
- Using ReplicaSet underneath
  - Maintain a stable set of replica Pods at any given time
- Recommended way of deploying **stateless applications**

Why use Deployments and not Pods?

- Scaling
- Updates and Rollbacks
- Self-healing
- Load Balancing and Network Policies

Deployment Strategies and Rollback

- Strategies
  - Recreate (all existing Pods are killed before new ones are created)
  - RollingUpdate (default, Pods are updated in a rolling fashion)
- Rollback – ability to fix errors or mistakes
  - Undo to previous revision
  - Rolling back to specified revision from history

Lab 3.4 - Deployments

- Create a Deployment from manifest
- Scale created deployment
- Demonstrate manual deletion of a replica
- Upgrade the existing deployment
- Rollback to the first revision

ConfigMaps

- An API object used to store **non-confidential** data in key-value pairs
- Pods can consume them as:
  - Environment variables
  - Command line arguments
  - Configuration files in a volume
- Used to separate configuration from the app

Secrets

- An object that contains a small amount of sensitive data
- Similar to ConfigMaps, but intended to hold **confidential data**
- **Stored unencrypted in the etcd**
  - Enable encryption at Rest,
  - enable or configure RBAC,
  - restrict Secret access to a specific containers,
  - consider using external Secret store providers

Lab 3.5 – ConfigMaps and Secrets

- Create a ConfigMap
- Map it to a running object as a configuration parameter
- Create a Secret
- Map it to a running object as a volume

DaemonSets

- Ensures that all (or some) Nodes run a copy of a Pod
- Typical use cases
  - Running a cluster storage daemon
  - Running a logs collection daemon
  - Running a node monitoring daemon

```yaml
apiVersion: apps/v1
kind: DaemonSet
metadata:
  name: fluentd-elasticsearch
  namespace: kube-system
  labels:
    k8s-app: fluentd-logging
spec:
  selector:
    matchLabels:
      name: fluentd-elasticsearch
  template:
    metadata:
      labels:
        name: fluentd-elasticsearch
    spec:
      tolerations:
      # these tolerations are to have the daemonset runnable on control plane nodes
      # remove them if your control plane nodes should not run pods
      - key: node-role.kubernetes.io/control-plane
        operator: Exists
        effect: NoSchedule
      - key: node-role.kubernetes.io/master
        operator: Exists
        effect: NoSchedule
      containers:
      - name: fluentd-elasticsearch
        image: quay.io/fluentd_elasticsearch/fluentd:v2.5.2
        volumeMounts:
        - name: varlog
          mountPath: /var/log
      terminationGracePeriodSeconds: 30
      volumes:
      - name: varlog
        hostPath:
          path: /var/log
```

Jobs

- Creates one or more Pods
- Continues to retry execution until a specified number of them successfully terminate
- Use cases:
  - Run a Pod to its completion
  - Database configuration
  - Smoke tests

```yaml
apiVersion: batch/v1
kind: Job
metadata:
  name: pi
spec:
  template:
    spec:
      containers:
      - name: pi
        image: perl:5.34.0
        command: ["perl",  "-Mbignum=bpi", "-wle", "print bpi(2000)"]
      restartPolicy: Never
  backoffLimit: 4
```

CronJobs

- Creates a Job on a repeating schedule
- Meant to perform regular, scheduled actions
- Similar concept to a crontab in Unix systems
- Use cases:
  - Backups
  - Report generation

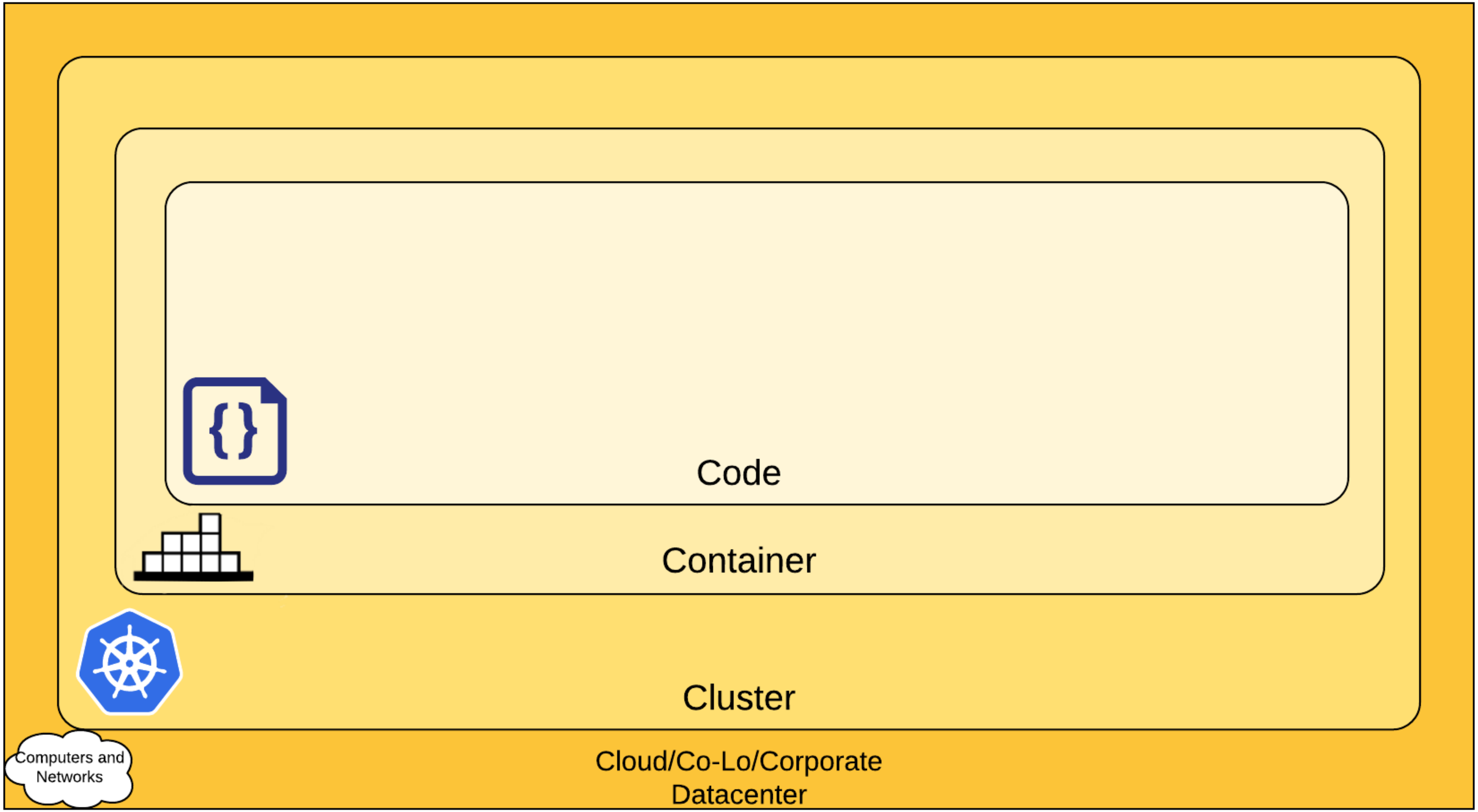
```yaml
apiVersion: batch/v1
kind: CronJob
metadata:
  name: hello
spec:
  schedule: "* * * * *"
  jobTemplate:
    spec:
      template:
        spec:
          containers:
          - name: hello
            image: busybox:1.28
            imagePullPolicy: IfNotPresent
            command:
            - /bin/sh
            - -c
            - date; echo Hello from the Kubernetes cluster
          restartPolicy: OnFailure
```

4. Security

Authentication, RBAC, ServiceAccount, SecurityContext

Cloud Native Security

- 4C’s
  - Cloud
  - Cluster
  - Container
  - Code


Code
Container
Cluster
Computers and Networks
Cloud/Co-Lo/Corporate Datacenter

Cluster Security

- Securing the components of the cluster
  - Controlling access to Kubernetes API
  - Controlling the capabilities
  - Protecting cluster components from compromise
- Securing the components in the cluster
  - **RBAC Authorization, Authentication**, Application secrets management, Pods alignment to Pod Security Standards, QoS, **Network Policies**, TLS for Kubernetes Ingress

Authentication

- Process verifying the ID of a user or a Service trying to access the API
- Categories of users
  - Normal users
  - ServiceAccounts managed by Kubernetes

Authentication Strategies

- Ways to authenticate
  - Client Certificates
  - Bearer tokens
  - Authenticating proxy (to enable LDAP, SAML, Kerberos...)
- Following attributes are associated with the request:
  - Username
  - UID
  - Groups (system:masters, or system-users)
  - Extra fields

ServiceAccounts

- Non-human account that provides distinct identity in a K8s cluster
- Properties: namespaced, lightweight, portable
- Some use cases:
  - Pods need to communicate with K8s API
  - Pods need to communicate with an external service
  - Authenticating to private image registry

```yaml
apiVersion: v1
kind: ServiceAccount
metadata:
  name: default
  namespace: default
imagePullSecrets:
  - name: myregistrykey
```

RBAC Authorization

- Role-based access control
- Regulating access based on the roles of individual users
- By default, RBAC is enabled on the cluster

RBAC Objects

- Namespace-scoped
  - Role
  - RoleBinding
- Cluster-scoped
  - ClusterRole
  - ClusterRoleBinding

Role and ClusterRole

- Contain rules that represent a set of permissions
- Permissions are additive (no “deny” rules)
- When to use ClusterRole
  - Define permissions on a namespaced resource and be granted access within individual namespaces
  - Define permissions on a namespaced resources and be granted across all namespaces
  - Define permissions on cluster-scoped resources

```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: Role
metadata:
  namespace: default
  name: pod-reader
rules:
- apiGroups: [""] # "" indicates the core API group
  resources: ["pods"]
  verbs: ["get", "watch", "list"]
```

```yaml
apiVersion: rbac.authorization.k8s.io/v1
kind: ClusterRole
metadata:
  # "namespace" omitted since ClusterRoles are not namespaced
  name: secret-reader
rules:
- apiGroups: [""]
  #
  # at the HTTP level, the name of the resource for accessing Secret
  # objects is "secrets"
  resources: ["secrets"]
  verbs: ["get", "watch", "list"]
```

RoleBinding and ClusterRoleBinding

- Grant permissions defined in a role
- RoleBinding may reference any Role within the same Namespace
- RoleBinding can reference a ClusterRole and bind it to specific Namespace
- ClusterRoleBinding references only ClusterRole

```yaml
apiVersion: rbac.authorization.k8s.io/v1
# This role binding allows "jane" to read pods in the "default" namespace.
# You need to already have a Role named "pod-reader" in that namespace.
kind: RoleBinding
metadata:
  name: read-pods
  namespace: default
subjects:
# You can specify more than one "subject"
- kind: User
  name: jane # "name" is case sensitive
  apiGroup: rbac.authorization.k8s.io
roleRef:
  # "roleRef" specifies the binding to a Role / ClusterRole
  kind: Role #this must be Role or ClusterRole
  name: pod-reader # this must match the name of the Role or ClusterRole you
wish to bind to
  apiGroup: rbac.authorization.k8s.io
```

```yaml
apiVersion: rbac.authorization.k8s.io/v1
# This cluster role binding allows anyone in the "manager"
group to read secrets in any namespace.
kind: ClusterRoleBinding
metadata:
  name: read-secrets-global
subjects:
- kind: Group
  name: manager # Name is case sensitive
  apiGroup: rbac.authorization.k8s.io
roleRef:
  kind: ClusterRole
  name: secret-reader
  apiGroup: rbac.authorization.k8s.io
```

SecurityContext

- Defines privilege and access control settings for a Pod or Container
- Some security context settings:
  - Permission to access an object
  - SELinux
  - Running as privileged on unprivileged
  - Linux Capabilities

```yaml
apiVersion: v1
kind: Pod
metadata:
  name: security-context-demo
spec:
  securityContext:
    runAsUser: 1000
    runAsGroup: 3000
    fsGroup: 2000
  volumes:
  - name: sec-ctx-vol
    emptyDir: {}
  containers:
  - name: sec-ctx-demo
    image: busybox:1.28
    command: [ "sh", "-c", "sleep 1h" ]
    volumeMounts:
    - name: sec-ctx-vol
      mountPath: /data/demo
    securityContext:
      allowPrivilegeEscalation: false
```

5. Storage

Persistent Storage in K8s, PersistentVolumes, CSI, StorageClass, StatefulSets

Persistent Storage in K8s

- K8s initially built for stateless applications
- Support for stateful applications built during the time
- Nowadays – everyone recommends to run stateful applications on K8s
  - e.g. StatefulSets

PersistentVolumes

- A piece of storage in the cluster
- K8s object
- Types of provisioning
  - Static – manually, using PersistentVolume manifest
  - Dynamic – with StorageClass and PersistentVolumeClaim

Dynamic Provisioning of a PV

- StorageClass
  - Way to describe a “class” of a storage offered
  - We can have multiple Scs
  - provisioner, parameters, and reclaimPolicy fields
- PersistentVolumeClaim
  - Request for storage by a user

Lifecycle of a volume and claim

- Provisioning (static or dynamic)
- Binding
- Using (multiple Pods can use same volume if underlying storage technology supports it, e.g. NFS)
- Reclaiming (what to do with a volume after released)
  - Retain
  - Delete

Lab 5.1 – static provisioning of PersistentVolume

- Create a PV and a PVC manifest
- Create a workload which uses the PVC
- Test the persistence
- Delete the workload and see what happens

Lab 5.2 – dynamic provisioning of PersistentVolume

- Show a SC
- Create a workload with a PVC
- Test the persistence
- Delete the workload and see what happens
- Demonstrate expansion of PVC

StatefulSets

- Object that allows to manage **stateful** applications
- Provides guarantee about the ordering and uniqueness of Pods
- Use PVCs
- Upon deletion, PVs are kept

StatefulSets vs Deployments

- Deployments used for stateless applications
- Pod identity varies – in StatefulSets is static (starting from 0), while in Deployments dynamic
- Storage – each replica in a StatefulSet has its own PVC and PV
- Network identity – Deployments require a service, while StatefulSets uses headless service
- Scaling – stateful apps, can result in a loss of data → StatefulSets

Lab 5.3 – StatefulSets

- Create a StatefulSet with a PVC from Manifest
- Scale it up/down
- Demonstrate deletion and the resulting storage

Container Storage Interface

- Standard for exposing storage systems to Containers
- Storage providers can write a CSI plugin without touching the core
- More options for users
- More complexity

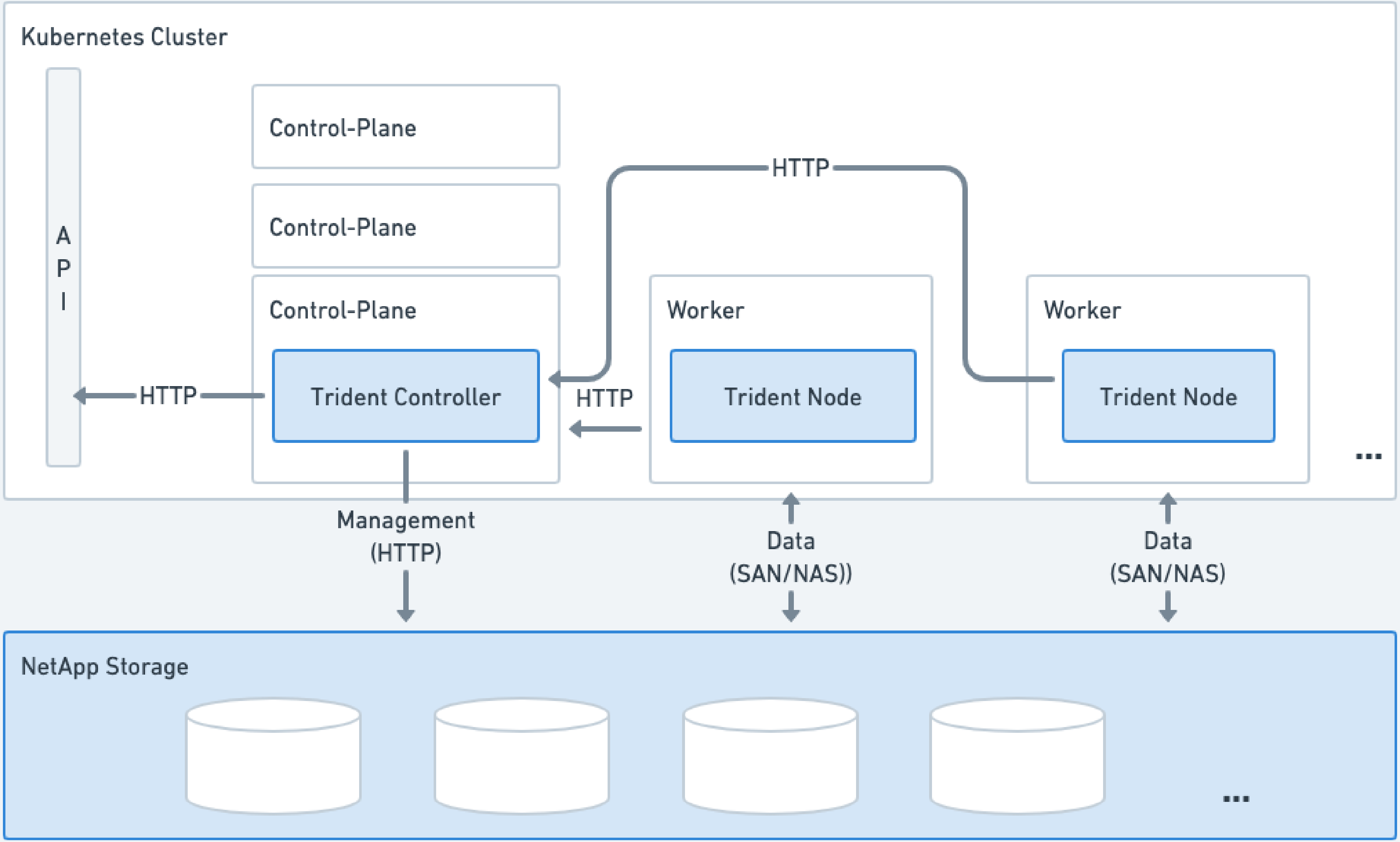
CSI Implementations

- Azure Disks, Files, and Blob storage CSI drivers
- AWS EBS, EFS CSI drivers
- GKE Persistent Disk, Filestore, Storage CSI drivers
- NetApp Trident
- Complete list of drivers
- You can have multiple drivers installed

Example steps to install Astra (NetApp) Trident

- Install Trident via tridentctl or Operator
- Prepare worker nodes with NFS or iSCSI drivers
- Configure backend (how to communicate with storage)
- Configure StorageClass
- Provision a volume

Quick start Guide


Kubernetes Cluster
A P I
Control-Plane
Control-Plane
Control-Plane
HTTP
Trident Controller
HTTP
HTTP
Worker
Trident Node
Worker
Trident Node
...
Management (HTTP)
Data (SAN/NAS))
Data (SAN/NAS)
NetApp Storage
...

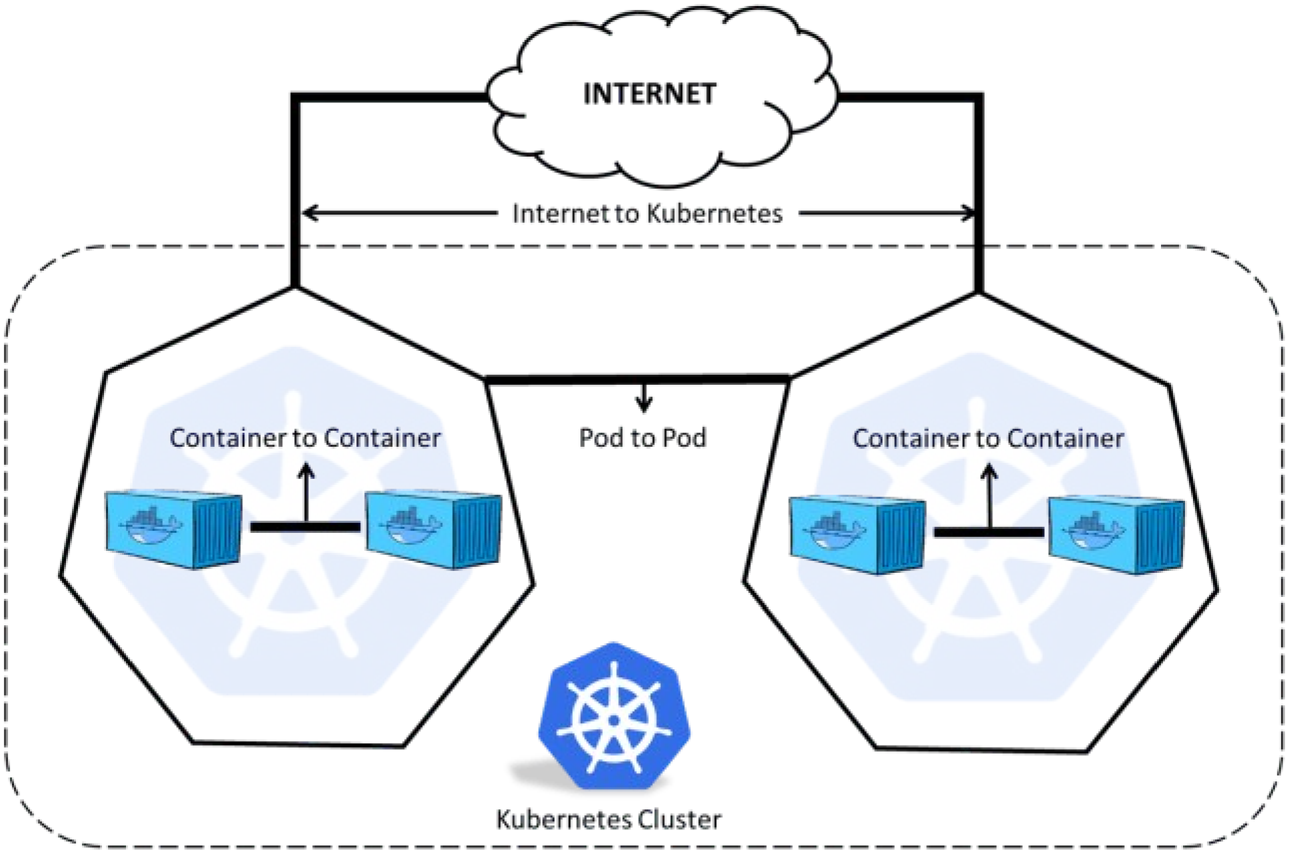
6. Networking

Services, LoadBalancers, Ingress and IngressControllers, NetworkPolicies, and CNI

Networking Model

- Every Pod is a separate host
  - Containers within them as a processes
- Types of communication:
  - Container to container – solved by Pods and localhost comms
  - Pod to Pod – every Pod has its own IP
  - Pod to Service – Services expose one or more Pods to the outside (Load Balancers)
  - External to Service – typically handled by IngressController

Kubernetes Networking Model



Services

- Method of exposing an App running in one or more Pods
- Defines a logical set of endpoints (usually Pods), and how to make them available
- Set of targeted Pods determined by selector field
- Act as a Load Balancers to Pods

Service Types

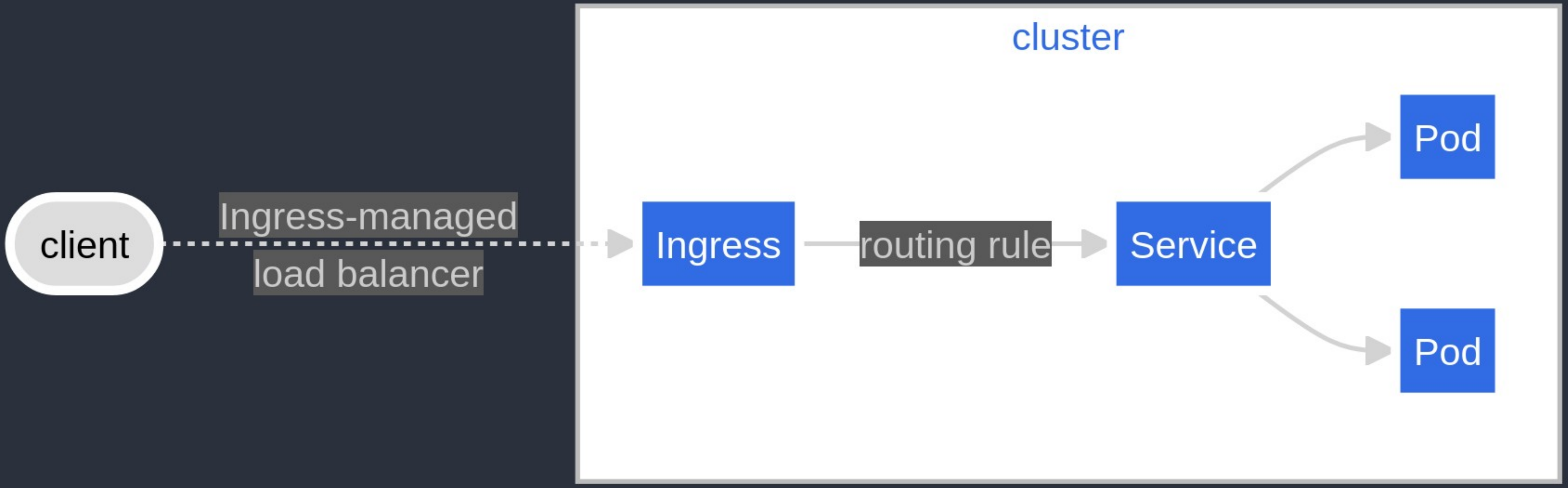
- ClusterIP
  - Default value; exposes the Service on a cluster-internal IP
- NodePort
  - Exposes the Service on each Node’s IP at a static port
- LoadBalancer
  - Exposes the Service externally, using external LB
- ExternalName
  - Maps the service to the contents of externalName field
- .spec.clusterIP: “None”
  - *Headless Service,* a cluster IP is not allocated, no proxy, or LB
  - A mechanism for providing a direct connection to the Pods

Lab 6.1 - Services

- Create a Pod and tie it to a service
- Demonstrate a connection from other Pod
- Delete a Service
- Demonstrate impact

Ingress

- Exposes HTTP and HTTPS routes from outside the cluster
- It connects to services within
- Not useful without IngressController
- It acts as a rule
- It provides:
  - Load balancing,
  - SSL termination,
  - name-based virtual hosting


client
Ingress-managed
load balancer
cluster
Ingress
routing rule
Service
Pod
Pod

IngressController

- Enables Ingress
- Not started automatically with a cluster
- Various projects are supported officially
  - AWS LB
  - GCE
  - nginx

Lab 6.2 – Ingress and IngressController

- Demonstrate IngressController on GKE
- Create an Ingress from manifest
- Test the publicly available IPs

NetworkPolicy

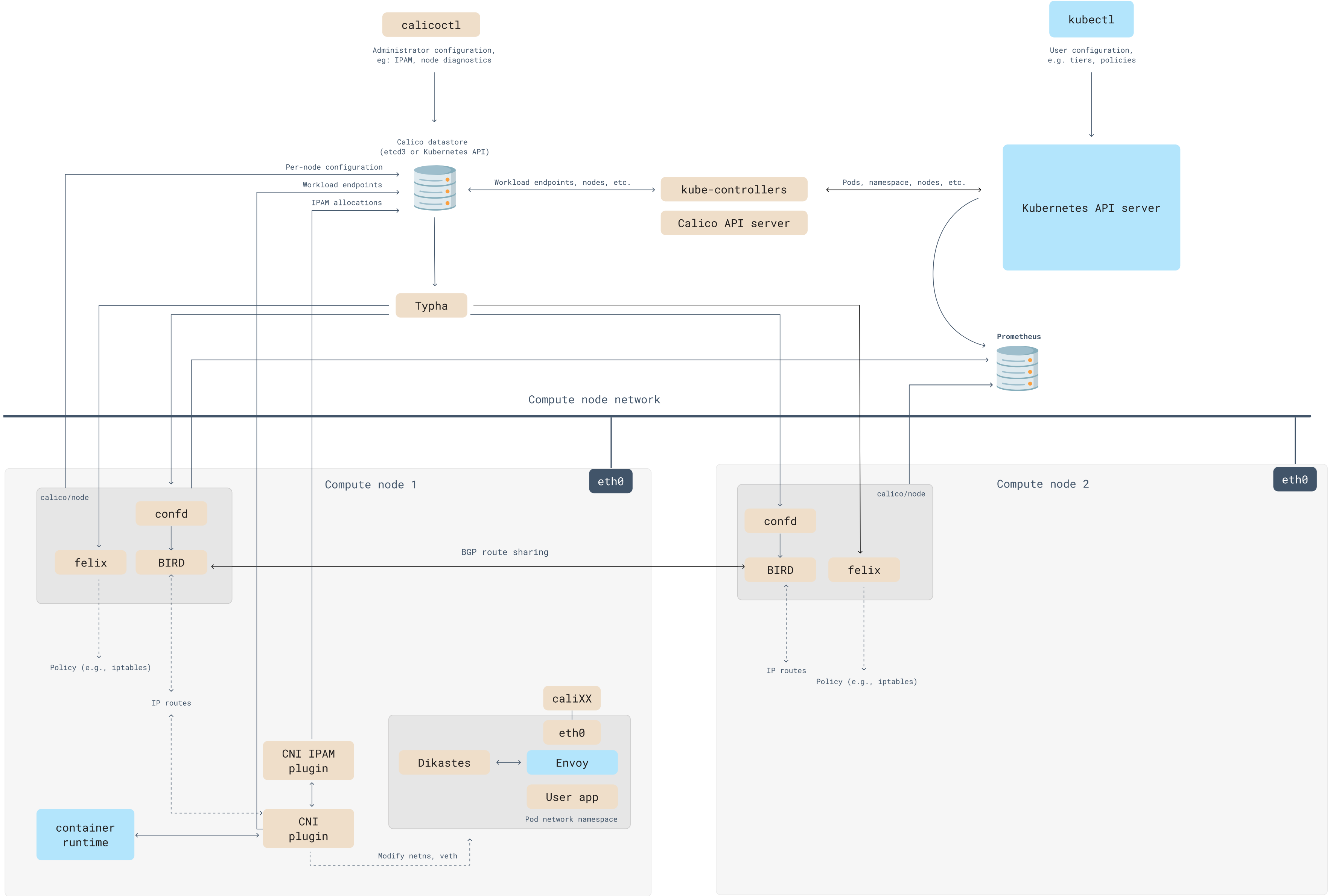
- Control traffic at IP or port level
- How a Pod is allowed to communicate with various network “entities”
- Apply to connection with a Pod on one or both ends
- Entities
  - Other Pods
  - Namespaces
  - IP blocks

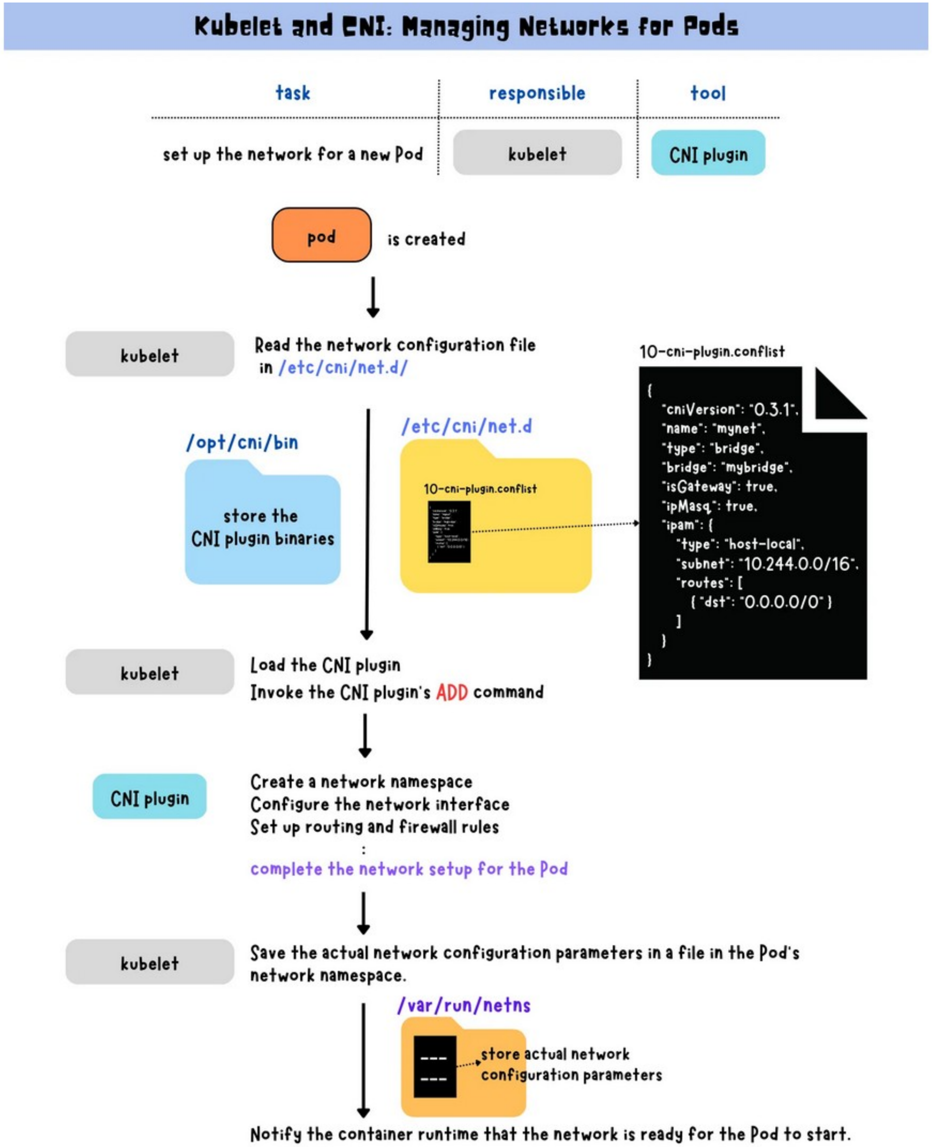
Lab 6.3 – NetworkPolicy

- Create a NetworkPolicy from manifest
- Demonstrate the connection
- Demonstrate denying connection
- Remove the NP and see the outcome

Container Network Interface

- Set of standards how network should be handled in Kubernetes
- A framework for dynamically configuring networking resources
- How it works:
  - Creating network interface for a container
  - Configuring the network inside of a container
  - Assigning the IP to the interface (Pod) and setting up the routes
- Allows different plugins to be used with container runtimes


calicoctl
Administrator configuration, eg: IPAM, node diagnostics
kubectl
User configuration, e.g. tiers, policies
Calico datastore (etcd3 or Kubernetes API)
Per-node configuration
Workload endpoints
IPAM allocations
Workload endpoints, nodes, etc.
kube-controllers
Calico API server
Pods, namespace, nodes, etc.
Kubernetes API server
Typha
Prometheus
Compute node network
Compute node 1
eth0
calico/node
confd
felix
BIRD
BGP route sharing
Policy (e.g., iptables)
IP routes
caliXX
eth0
Dikastes
Envoy
User app
Pod network namespace
CNI IPAM plugin
CNI plugin
container runtime
Modify netns, veth
Compute node 2
eth0
calico/node
confd
BIRD
felix
IP routes
Policy (e.g., iptables)


Kubelet and CNI: Managing Networks for Pods
task
responsible
tool
set up the network for a new Pod
kubelet
CNI plugin
pod
is created
kubelet
Read the network configuration file in /etc/cni/net.d/
/opt/cni/bin
store the CNI plugin binaries
/etc/cni/net.d
10-cni-plugin.conflist
10-cni-plugin.conflist
{
"cniVersion": "0.3.1",
"name": "mynet",
"type": "bridge",
"bridge": "mybridge",
"isGateway": true,
"ipMasq": true,
"ipam": {
"type": "host-local",
"subnet": "10.244.0.0/16",
"routes": [
{ "dst": "0.0.0.0/0" }
]
}
}
kubelet
Load the CNI plugin
Invoke the CNI plugin's ADD command
CNI plugin
Create a network namespace
Configure the network interface
Set up routing and firewall rules
complete the network setup for the Pod
kubelet
Save the actual network configuration parameters in a file in the Pod's network namespace.
/var/run/netns
store actual network configuration parameters
Notify the container runtime that the network is ready for the Pod to start.

Source

7. Other Tools and Principles

Helm and Kustomize, GitOps principles and tools, Amazon EKS

Kustomize

- Configuration management tool
- Define and manage K8s objects in a declarative manner
- Features:
  - Customize untemplated YAML files
  - Generate resources
  - Preserve base settings
  - Reusability
- Embedded in Kubernetes, use apply -k

File Structure

```
hello-world/
├── base
│   ├── deployment.yaml
│   └── kustomization.yaml
└── overlays
    ├── production
    │   ├── replica_count.yaml
    │   └── kustomization.yaml
    └── staging
        ├── replica_count.yaml
        └── kustomization.yaml
```

Example

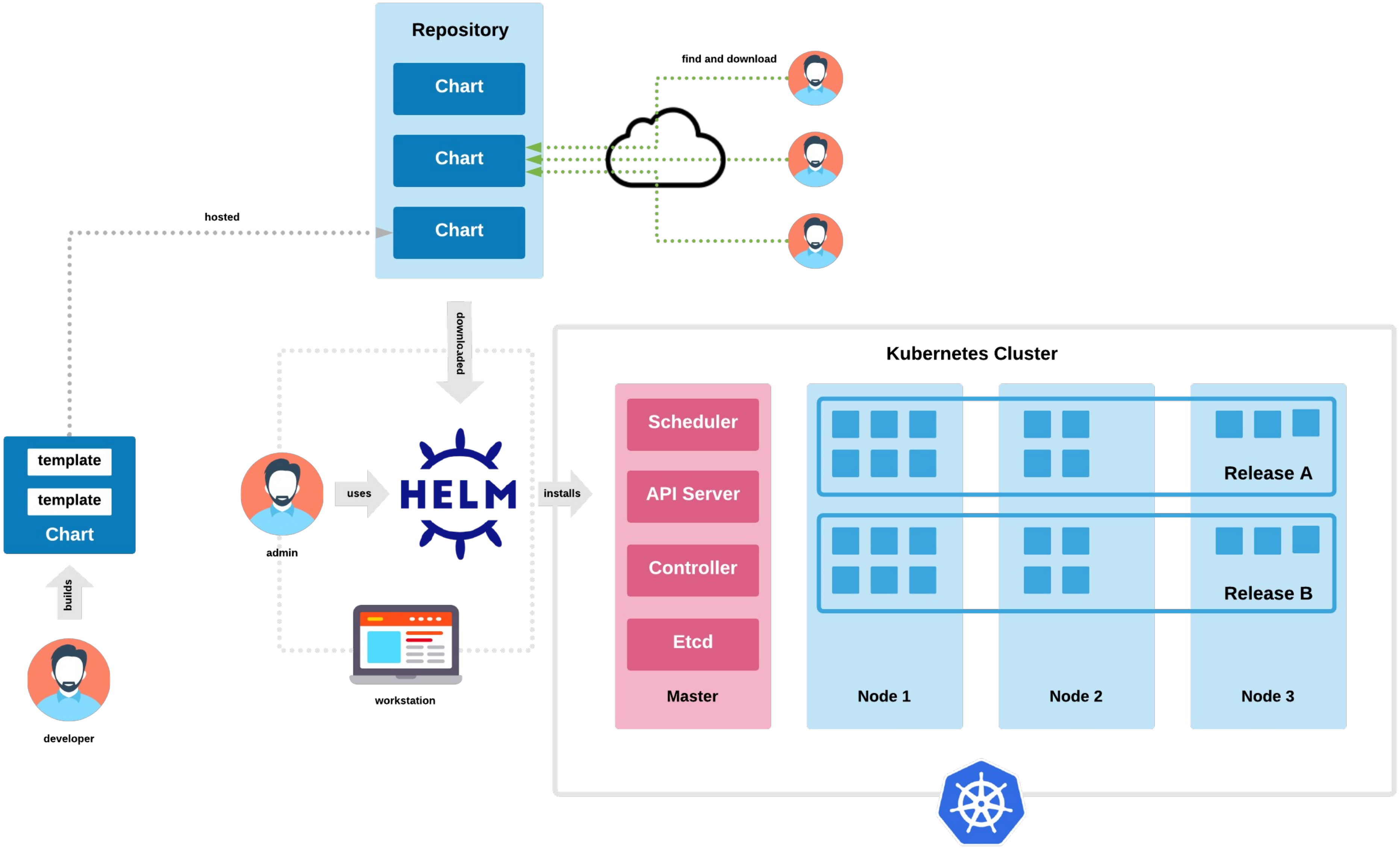
```
# Create a application.properties file
cat <<EOF >application.properties
FOO=Bar
EOF

cat <<EOF >./kustomization.yaml
configMapGenerator:
- name: example-configmap-1
  files:
  - application.properties
EOF

# The generated ConfigMap can be examined with the
following command:
kubectl kustomize ./
```

Helm

- Packaging manager for Kubernetes
- Main concept – Chart
- Packages multiple resources (e.g. Deployments, StatefulSets, Jobs, ServiceAccounts)
- Advantages:
  - Manages complexity
  - Easy update
  - Simple sharing
  - Easy rollback

Helm Chart Structure

```
mychart
|-- .helmignore # Contains patterns to ignore
|-- Chart.yaml # Information about your chart
|-- values.yaml # The default values for your templates
|-- NOTES.txt # Notes for deployment
|-- charts/ # Charts that this chart depends on
|-- templates/ # The template files
|-- tests/ # The test files
```



Repository
Chart
Chart
Chart
find and download
hosted
downloaded
Kubernetes Cluster
template
template
Chart
builds
developer
admin
uses
HELM
installs
workstation
Scheduler
API Server
Controller
Etcd
Master
Release A
Release B
Node 1
Node 2
Node 3

Lab 7.1 - Helm

- Check the structure of a Helm Chart
- Deploy a Helm chart
- Demonstrate the history
- Demonstrate upgrading
- Demonstrate rollback
- Package a helm chart

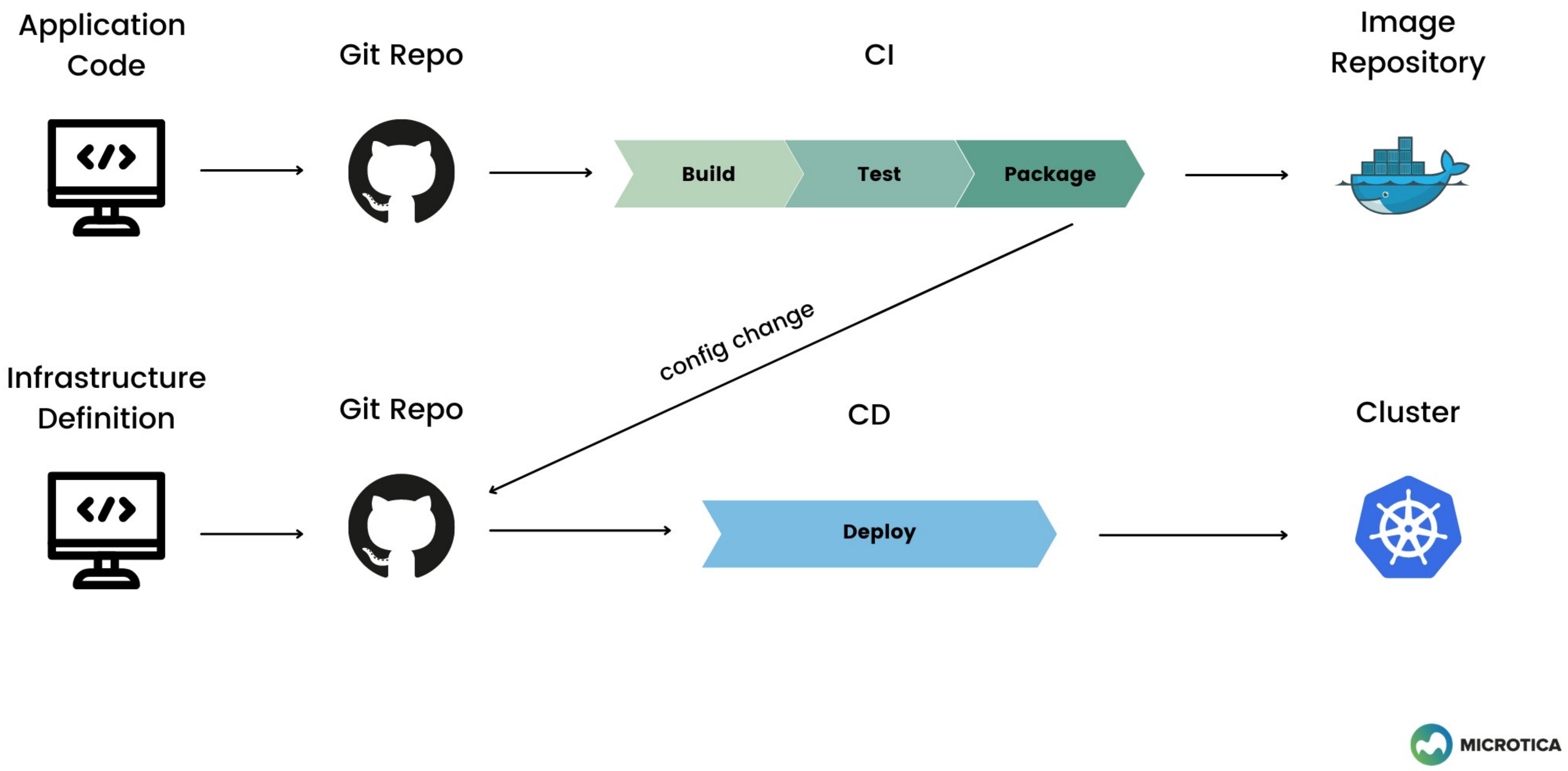
GitOps

- Operational framework that applies DevOps best practices to infrastructure automation
- Git repository is a single source of truth
- Automates the process of provisioning infrastructure
- Idempotent – generate same results every time it’s deployed

Key components of GitOps Workflow

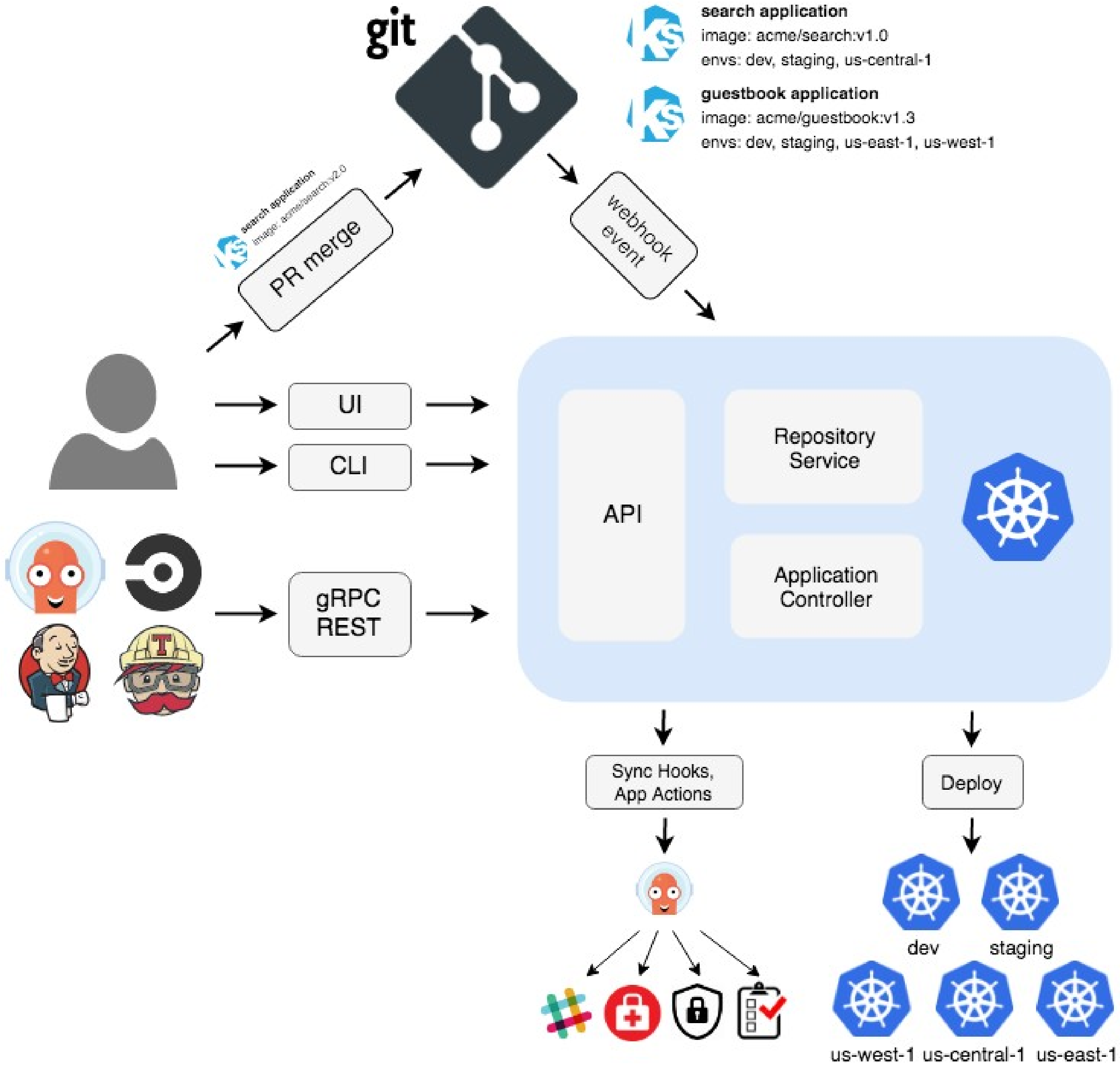
- Git repository is the single source of truth for app configuration and code
- CD pipeline responsible for build, test, and deploy of the app
- Deployment tools used to manage the app resources in the target environment
- Monitoring system tracks the app performance and provides feedback

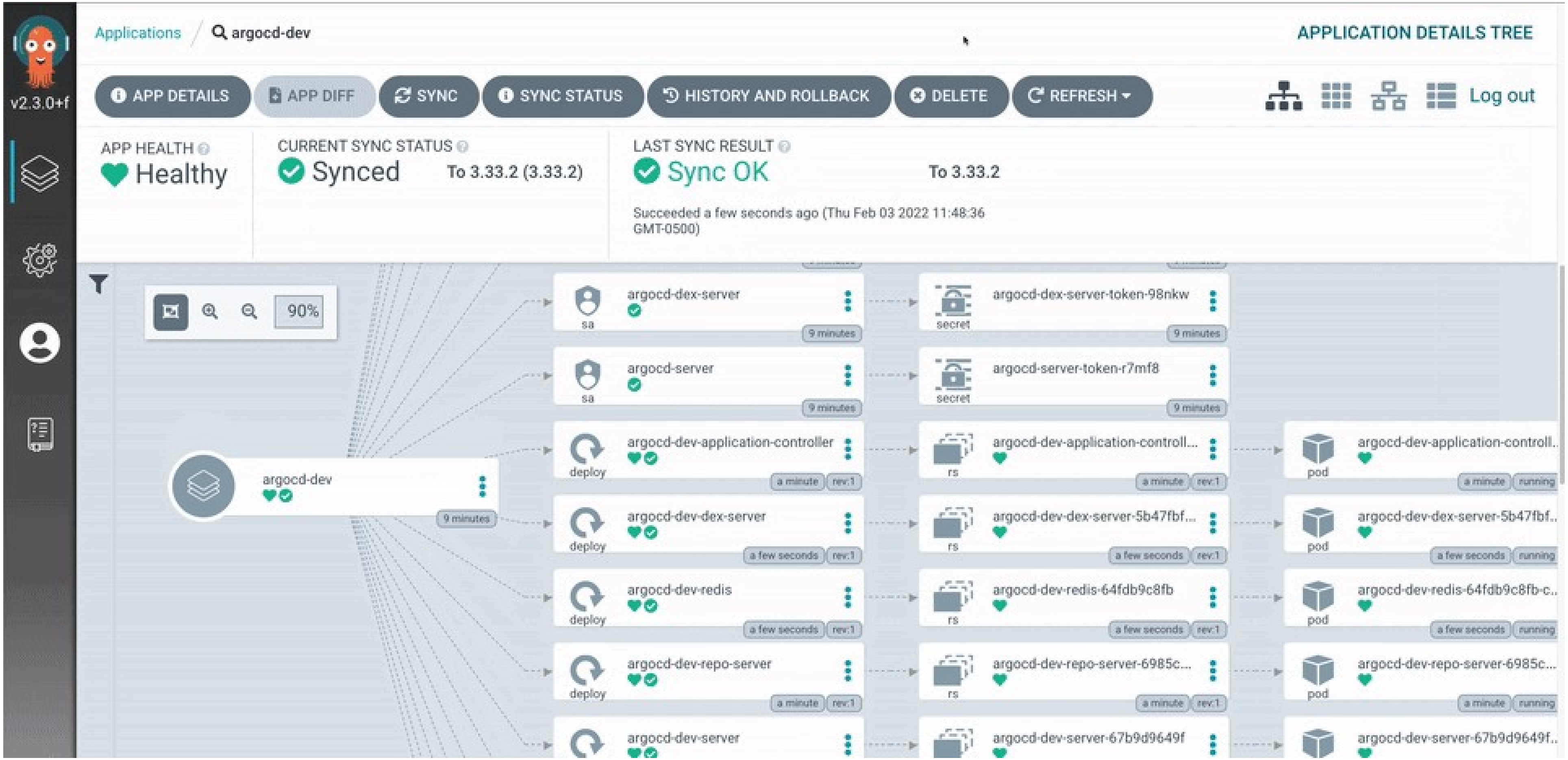
GitOps Workflow



ArgoCD

- Declarative GitOps CD tool
- K8s manifests specified in
  - Kustomize
  - Helm
  - Jsonnet files
  - Plain directory of YAML/json
  - Any custom config management tool
- Demo applications
- Demo ArgoCD

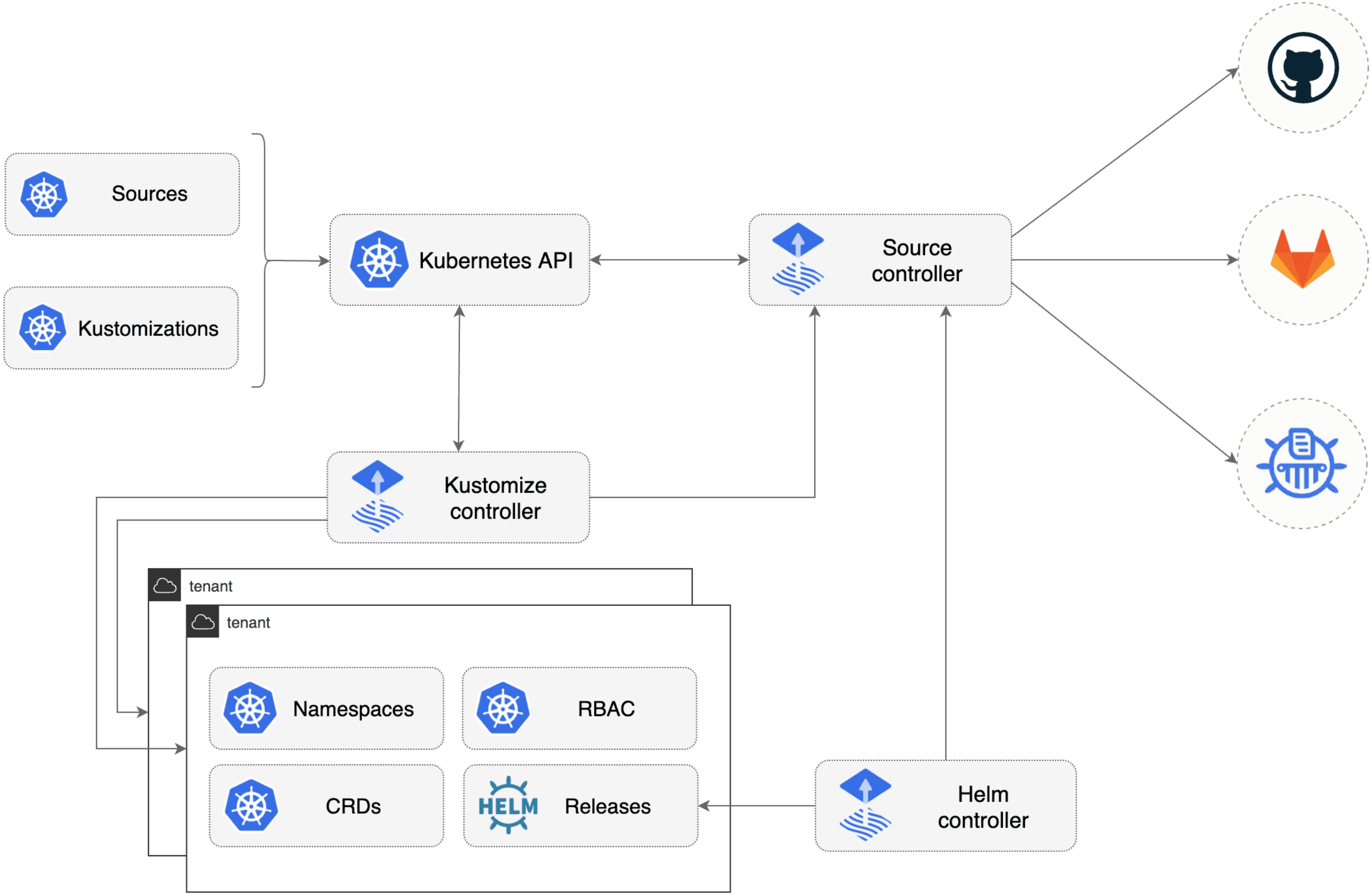

git
search application
image: acme/search:v1.0
envs: dev, staging, us-central-1
guestbook application
image: acme/guestbook:v1.3
envs: dev, staging, us-east-1, us-west-1
search application
image: acme/search:v2.0
PR merge
webhook event
UI
CLI
gRPC REST
API
Repository Service
Application Controller
Sync Hooks, App Actions
Deploy
dev
staging
us-west-1
us-central-1
us-east-1



Applications
argocd-dev
APPLICATION DETAILS TREE
v2.3.0+f
APP DETAILS
APP DIFF
SYNC
SYNC STATUS
HISTORY AND ROLLBACK
DELETE
REFRESH
Log out
APP HEALTH
Healthy
CURRENT SYNC STATUS
Synced
To 3.33.2 (3.33.2)
LAST SYNC RESULT
Sync OK
To 3.33.2
Succeeded a few seconds ago (Thu Feb 03 2022 11:48:36 GMT-0500)
90%
argocd-dev
9 minutes
argocd-dex-server
sa
argocd-server
argocd-dev-application-controller
deploy
argocd-dev-dex-server
argocd-dev-redis
argocd-dev-repo-server
argocd-dev-server
argocd-dex-server-token-98nkw
secret
argocd-server-token-r7mf8
argocd-dev-application-controll...
rs
argocd-dev-dex-server-5b47fbf...
argocd-dev-redis-64fdb9c8fb
argocd-dev-repo-server-6985c...
argocd-dev-server-67b9d9649f
pod
argocd-dev-redis-64fdb9c8fb-c...
argocd-dev-server-67b9d9649f...
a minute
a few seconds
rev:1
running

Flux

- Provides GitOps for both apps and infrastructure
- Features:
  - Automates provision and configuration of clusters
  - Enables continuous delivery for teams of platform engineers and developers
- Constructed with GitOps toolkit components
  - Specialized tools and Flux Controllers
  - Composable APIs
  - Reusable Go packages for GitOps


Sources
Kustomizations
Kubernetes API
Source controller
Kustomize controller
tenant
tenant
Namespaces
RBAC
CRDs
HELM
Releases
Helm controller

weavegitops

Applications

APPLICATIONS

SOURCES

FLUX RUNTIME

DOCS

SYNC

type: HelmRelease

Clear All

	NAME	KIND	NAMESPACE	TENANT	SOURCE	STATUS	MESSAGE	REVISION
☐	cert-manager	HelmRelease	cert-manager	sre-team	cert-manager-cert-manager	Ready	Release reconciliation succeeded	v1.11.0
☐	flagger	HelmRelease	flagger-system	sre-team	flagger-system-flagger	Ready	Release reconciliation succeeded	1.27.0
☐	ingress-nginx	HelmRelease	ingress-nginx	sre-team	ingress-nginx-ingress-nginx	Ready	Release reconciliation succeeded	4.4.2
☐	linkerd-control-plane	HelmRelease	linkerd	sre-team	linkerd-linkerd-control-plane	Ready	Release reconciliation succeeded	1.9.5
☐	linkerd-crds	HelmRelease	linkerd	sre-team	linkerd-linkerd-crds	Ready	Release reconciliation succeeded	1.4.0
☐	linkerd-smi	HelmRelease	linkerd-smi	sre-team	linkerd-smi-linkerd-smi	Ready	Release reconciliation succeeded	0.2.0
☐	linkerd-viz	HelmRelease	linkerd-viz	sre-team	linkerd-viz-linkerd-viz	Ready	Release reconciliation succeeded	30.3.5
☑	weave-gitops	HelmRelease	flux-system	-	flux-system-weave-gitops	Ready	Release reconciliation succeeded	4.0.12

ArgoCD vs Flux

- Multiple repository support
- All-inclusive GitOps solution with diverse features
- More complete GitOps solution
- Native Web UI

- One repository per instance of Flux operator
- Adaptability and customization with extensions
- Automate deployment pipeline and configuration management as a code
- Needs Web UI extension

Amazon Elastic Kubernetes Service

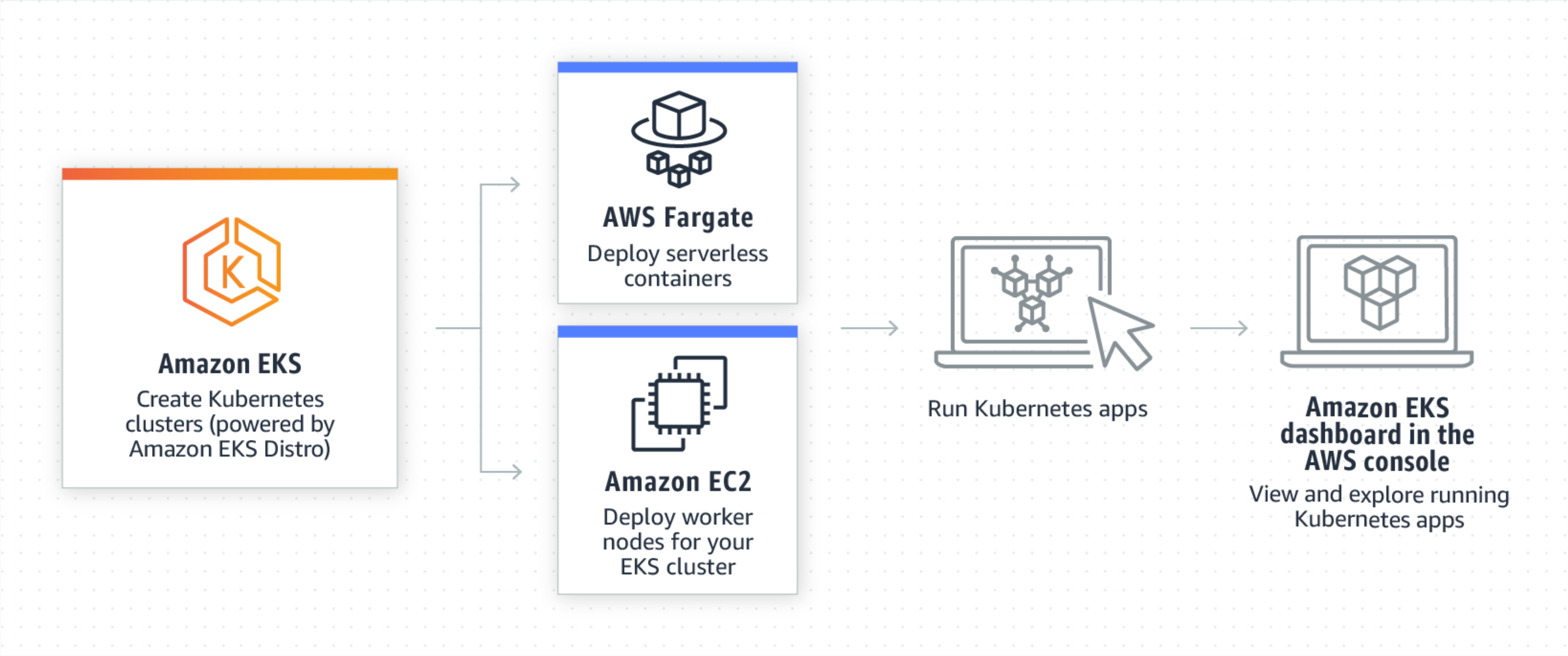
- Managed K8s service
- Eliminates the need to install, operate and maintain K8s control plane
- Price is $0.10 per hour per cluster
  - Plus price of EC2 resources if used (EBS, EC2 VMs)
  - If using AWS Fargate – based on the vCPU and memory used

Amazon EKS Features

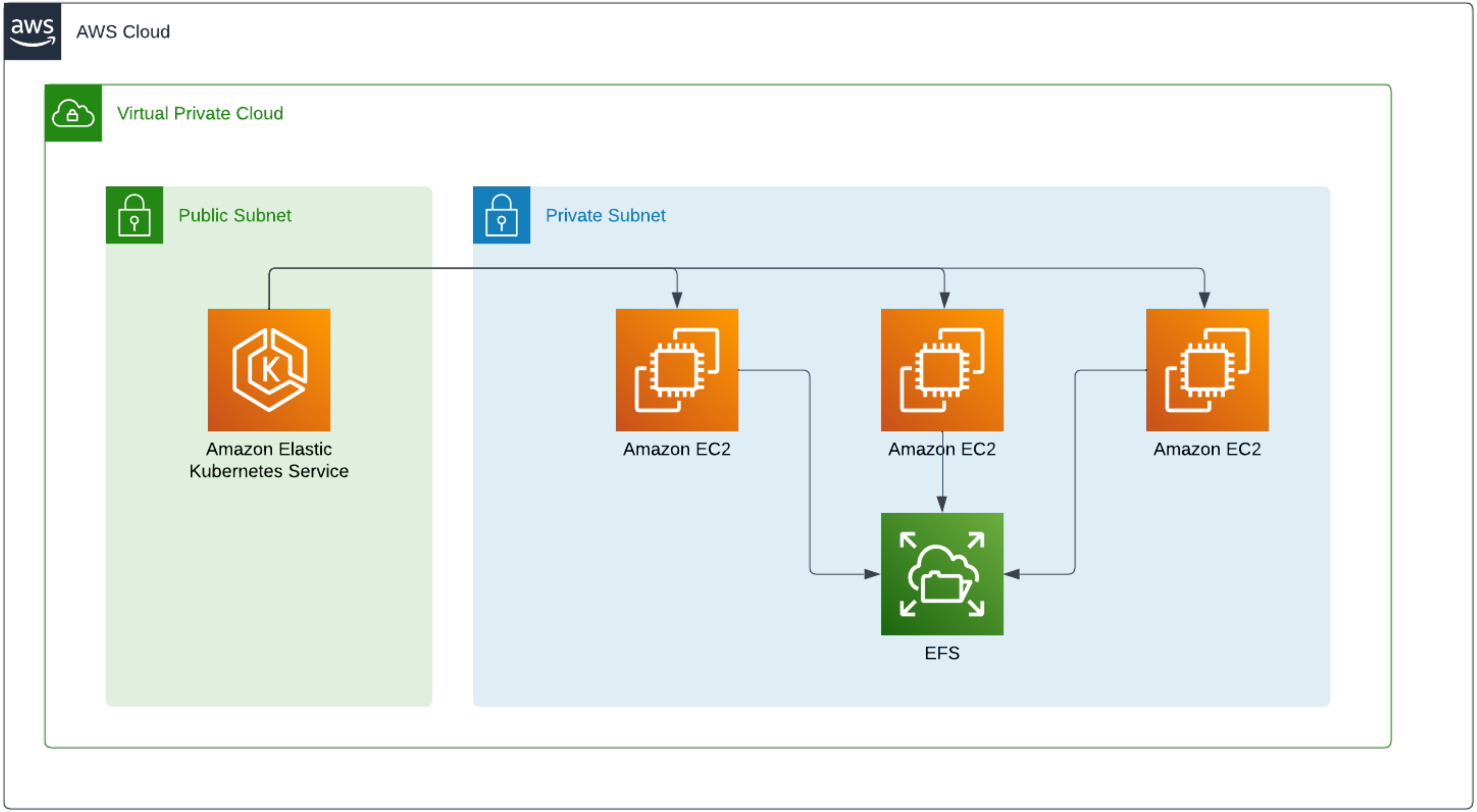
- High availability – run across multiple AZs
- Integration with other AWS services
- Scalability – easy, based on demand of workloads (it supports node autoscaling)
- Secure networking and authentication – integrated with AWS networking and security services
- Managed Node Groups – easily created, can use spot instances as cluster nodes

AWS Fargate

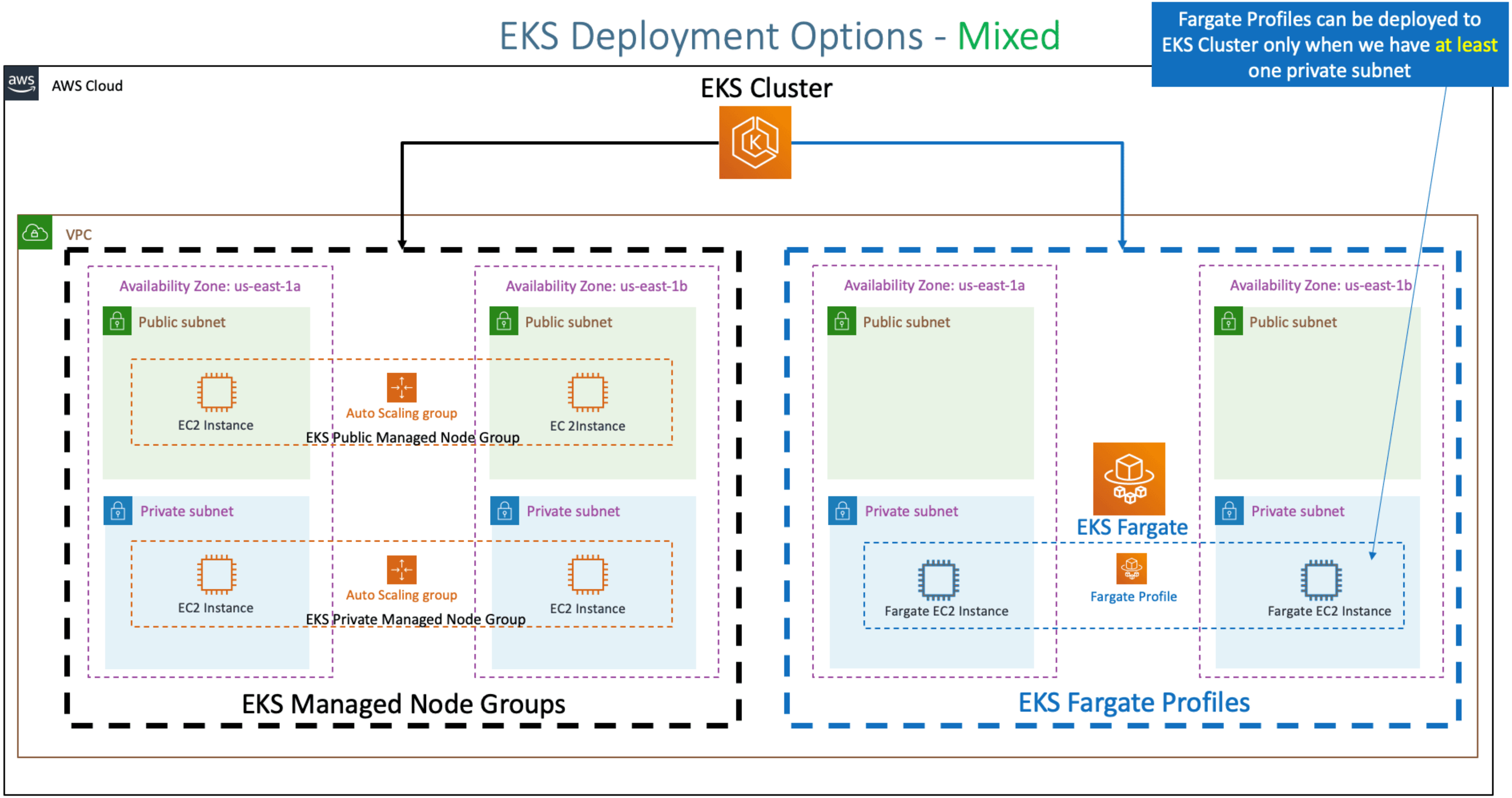
- Serverless compute engine for running containers
- Compatible with EKS and ECS
- How it works:
  - Serverless – no ned to manage servers or clusters of EC2 instances
  - Simplified management – no need for server types
  - Isolation – each Fargate task is isolated
  - Pay-as-you-go – focus on building apps insted of managing servers


Amazon EKS
Create Kubernetes clusters (powered by Amazon EKS Distro)
AWS Fargate
Deploy serverless containers
Amazon EC2
Deploy worker nodes for your EKS cluster
Run Kubernetes apps
Amazon EKS dashboard in the AWS console
View and explore running Kubernetes apps

Examples of EKS Architecture


AWS Cloud
Virtual Private Cloud
Public Subnet
Private Subnet
Amazon Elastic Kubernetes Service
Amazon EC2
Amazon EC2
Amazon EC2
EFS

EKS Deployment Options - Mixed



Closing remarks

- Sources used:
  - Kubernetes documentation
  - AWS EKS documentation
  - Helm
  - ArgoCD
  - Flux
  - GitOps
  - Docker
- Useful links
  - Kubernetes – where to start?
  - Kubernetes in Action
  - CKA Course on Udemy
  - CKS Course on Udemy

Thank you!

Link to the form